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Lockheed-Georgia

DESIGN OPTIONS STUDY
Final Report : Volume IV
Detailed Analysis
Supporting Appendices

LG80ER0009 September 1980

Final Report on Contract No. F33615-78-C-0122

LOCKHEED-GEORGIA COMPANY, Marietta, Georgia

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Prepared for

UNITED STATES AIR FORCE
Air Force Systems Command
Aeronautical Systems Division
Wright-Patterson AFB, Ohio 45433

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Advanced Civil/Military Aircraft (ACMA) is envisioned as an advanced-technology cargo aircraft with the potential for fulfilling the needs of both military airlift and commercial air freight in the 1990s and beyond. The ultimate goal of the Design Options Study is the development of fundamental information regarding both the military and commercial cost and effectiveness implications of the most signi[illegible]cant transport aircraft functional design features. This volume, the Detailed Analyses Supporting Appendices of the (Cont'd)

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Design Options Study Final Report, contains non-proprietary, detailed information and study methods used in the Study. This includes descriptions of the baseline aircraft that serve as the bases of the Qualitative Assessment; the computer-aided design methods used to assist in the redesign of aircraft incorporating each design option; and complete descriptions of each point design aircraft.

DESIGN OPTIONS STUDY

Volume IV: Detailed Analyses Supporting Appendices

LG80ER0009

September 1980

APPROVED BY: R H Lange
R. H. Lange, Manager
Advanced Concepts Department

LOCKHEED-GEORGIA COMPANY
A Division of Lockheed Corporation, Marietta, Georgia

FOREWORD

The Design Options Study was performed by Lockheed-Georgia for the Air Force Aeronautical Systems Division, Deputy for Development Planning, under Contract F33615-78-C-0122. This final report for the effort is presented in four volumes:

Volume I	Executive Summary
Volume II	Approach and Summary Results
Volume III	Qualitative Assessment
Volume IV	Detailed-Analysis Supporting Appendices

A fifth volume, describing the privately-developed analytical techniques used in this study has been documented as Lockheed Engineering Report LG80ER0015. NH This volume, which contains Lockheed Proprietary Data, will be furnished to the Government upon written request for the limited purpose of evaluating the other four volumes.

The Air Force program manager for this effort was Dr. L. W. Noggle; Dr. W. T. Mikolowsky was the Lockheed-Georgia study manager. Lockheed-Georgia personnel who participated in the Design Options Study include:

H. J. Abbey	Configuration Development
L. A. Adkins	Avionics
H. A. Bricker	Cost Analysis
E. W. Caldwell	Configuration Development
W. A. French	Propulsion and Noise Analysis
J. C. Hedstrom	Mission Analysis
J. F. Honrath	Aerodynamics
R. C. LeCroy	Mission Analysis
E. E. McBride	Stability and Control
A. McLean	Reliability
T. H. Neighbors	Maintainability
J. M. Norman	Commercial Systems Analysis
J. R. Peele	Mission Analysis
A. P. Pennock	Noise Analysis
C. E. Phillips	Maintainability
R. L. Rodgers	Mission Analysis
R. E. Stephens	Structures and Weights
R. L. Stowell	Mission Analysis
S. G. Thompson	Cost Analysis and Configuration Development
R. M. Thornton	Mission Analysis

Program management of the Design Options Study was the responsibility of the Advanced Concepts Department (R. H. Lange, manager) of the Advanced Design Division of Lockheed-Georgia.

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GLOSSARY

AAFIF	-	Automated Air Facility Information File
A/C	-	Aircraft
ACMA	-	Advanced Civil Military Aircraft
ADS	-	Aerial Delivery System
AEEC	-	Airline Electronic Engineering Committee
AFB	-	Air Force Base
ALICE	-	Aircraft Life Cycle Cost Evaluation
ANSER	-	Analytical Services, Inc.
APOD	-	Aerial Port of Debarkation
APOE	-	Aerial Port of Embarkation
ARINC	-	Aeronautical Radio, Inc.
ATA	-	Air Transport Association
¢/ATNM	-	Cents per Available Ton-Nautical Mile
CLASS	-	Cargo/Logistics Airlift Systems Study
combi	-	Combination Cargo/Passenger Aircraft
COMPASS	-	Computerized Movement Planning and Status System
CONUS	-	Continental United States
CRAF	-	Civil Reserve Air Fleet
DADS	-	Deterministic Airlift Development Simulation
DOC	-	Direct Operating Cost
E^3	-	Energy Efficient Engine
EPA	-	Environmental Protection Agency
FAA	-	Federal Aviation Administration
FAR	-	Federal Air Regulations
GRADE	-	GRaphics for Advanced Design Engineers
GASP	-	Generalized Aircraft Sizing and Performance

GLOSSARY (Cont'd)

GSPS	-	Global Satellite Positioning System
GSE	-	Ground Support Equipment
IADS	-	Innovative Aircraft Design Study
IFF/SIF	-	Identification: Friend or Foe/Selected Identification: Friend
IFR	-	Inflight Refueling
IOC	-	Initial Operational Capability
LCC	-	Life Cycle Costs
LCG	-	Load Classification Group
LCN	-	Load Classification Number
LD	-	Lower Deck
LIN	-	Line Item Number
L/D	-	Lift-to-Drag Ratio
LRU	-	Line Replaceable Unit
MAC	-	Military Airlift Command
NATO	-	North Atlantic Treaty Organization
NSN	-	National Stock Number
OR	-	Operational Readiness
O&S	-	Operation and Support
PAX	-	Passenger
POL	-	Petroleum, Oil, and Other Lubricants
RDT&E	-	Research, Development, Test and Evaluation
ROI	-	Return on Investment
RTCA	-	Radio Technical Commission
SAE	-	Society of Automotive Engineers
SFC	-	Specific Fuel Consumption
SKE	-	Station Keeping Equipment

GLOSSARY (Cont'd)

SRC	-	Standard Requirements Code (Army)
TACAN	-	Tactical Air Navigation
TOE	-	Tables of Organization and Equipment
UE	-	Unit Equipment
ULD	-	Unit Load device
UTC	-	Unit Type Code
ZFW	-	Zero Fuel Weight

APPENDIX A. DESCRIPTION OF THE BASELINE AIRCRAFT

This appendix describes the characteristics of the privately developed baseline aircraft used in the Design Options Study, designated the LGA-144-100. This aircraft served as the point of departure for the detailed analysis of the design payload options.

Configurational characteristics are presented first. In addition to the general arrangement, details relating to the specific design options incorporated in the baseline are shown. The technology level assumed in the development of the baseline aircraft is then discussed. Finally, some of the performance characteristics of the aircraft are presented.

CONFIGURATION

Figure A-1 presents the general arrangement of the -100. The optimization of this aircraft was performed on the basis of minimizing takeoff gross weight for the given design point subject to the following constraints:

- o 9500 ft takeoff distance over 50 ft
- o 2.5 percent engine-out second segment climb gradient
- o 0.85 maximum airfoil section lift coefficient in cruise

Figure A-2 displays the results of the final iteration of the optimization process that generated the baseline aircraft design. Since the cruise lift coefficient constraint noted above corresponds to a wing loading of 129.4 lb/sq ft at the baseline initial cruise altitude of 34,000 ft, the design point shown in Figure A-2 represents the intersection of the three aforementioned constraints.

Additional information regarding the structural weight and propulsion system characteristics of the baseline are included in the subsequent discussion of technology level.

CRUISE MACH NO.	0.78
DESIGN PAYLCAD	495,000 LB
DESIGN RANGE	4,000 NM
OPERATING WEIGHT	543,000 LB
MAX GROSS WEIGHT	1,370,000 LB
ASPECT RATIO	10.5
WING LOADING	129.4 PSF
THRUST PER ENGINE	80,000 LB

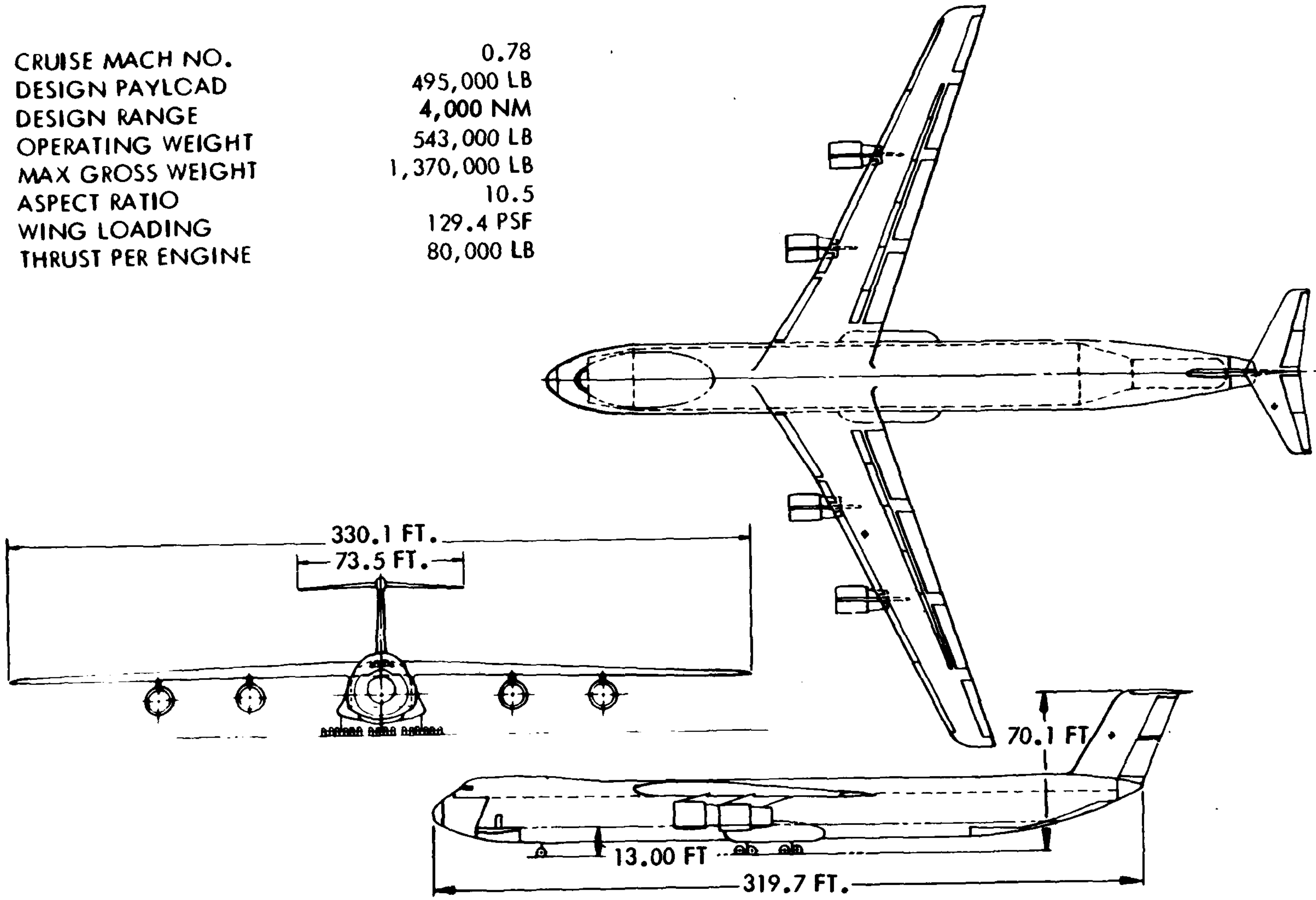


Figure A-1. Baseline Aircraft General Arrangement

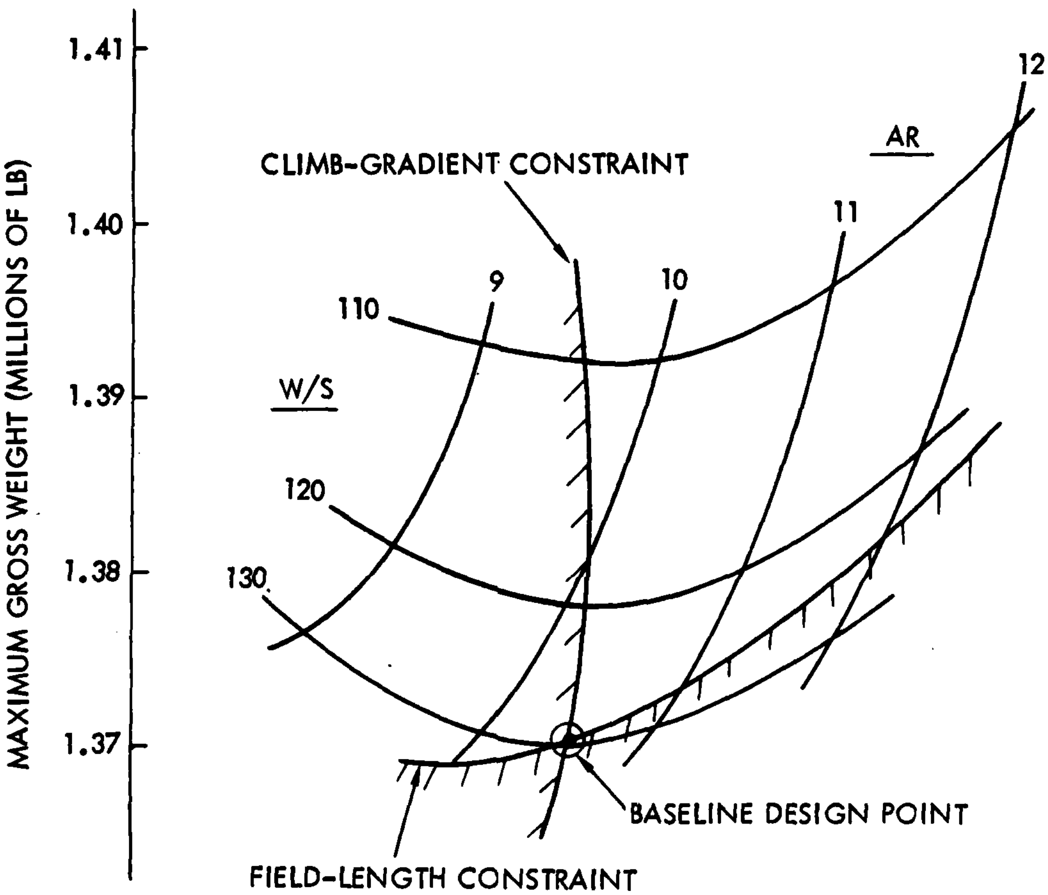


Figure A-2. Wing Loading and Aspect Ratio Carpet Plot Showing Final Design Point for the Baseline Aircraft

Details of the forward fuselage arrangement are given in Figure A-3. Note in particular the effect of tapering the cargo-compartment planform on the design of the front aperture and partially removable ramp system.

Figure A-4 presents similar details of the aft fuselage arrangement. The notable aspect of the present design is the single-piece, retractable pressure door. This arrangement eliminates the need for a separate pressure door at the aft end of the cargo compartment, which greatly simplifies ramp design. (In the C-5A, the ramp, when in the retracted position, also serves as the pressure door. This ramp/door mechanism is provided with hinges at both top and bottom. By using the lower hinges, the C-5A ramp/door can be extended as shown in Figure A-4; by using the upper hinges, the ramp/door can be positioned above and parallel to the cargo floor for air drop operations.) Another advantage of the present concept is that the last two ramp segments can be removed with no effect on the pressure seal. Finally, Figure A-4 demonstrates that vehicles with heights greater than 9.5 ft can readily be loaded through the aft aperture when the ramp is deployed in the drive-on position.

The landing gear arrangement is depicted in Figures A-5 and A-6. The baseline aircraft has an LCG II capability at maximum gross weight based on the use of B. F. Goodrich 50 by 20, Type VIII tires with a 32-ply rating.

Figure A-7 displays the layout of the flight station and relief crew compartment for the -100 baseline aircraft. Note that the layout shown assumes that a "third pilot" will fulfill the duties of both the navigator and flight engineer. This assumption is based on technology advances such as the Global Positioning Satellite System (GPSS) that should greatly reduce the navigation workload in most situations. Thus, the basic crew consists of three pilots and two loadmasters. For extended-duration flights (e.g., with one or more inflight refuelings), the basic crew would be augmented by the addition of three more pilots and, possibly, one or two more loadmasters.

Details of the cargo accommodation system are presented in Figures A-8a and 8b. This system is intended to accommodate a variety of containers and pallets as well as readily convert to a flat floor for vehicular loads. This conversion requires that:

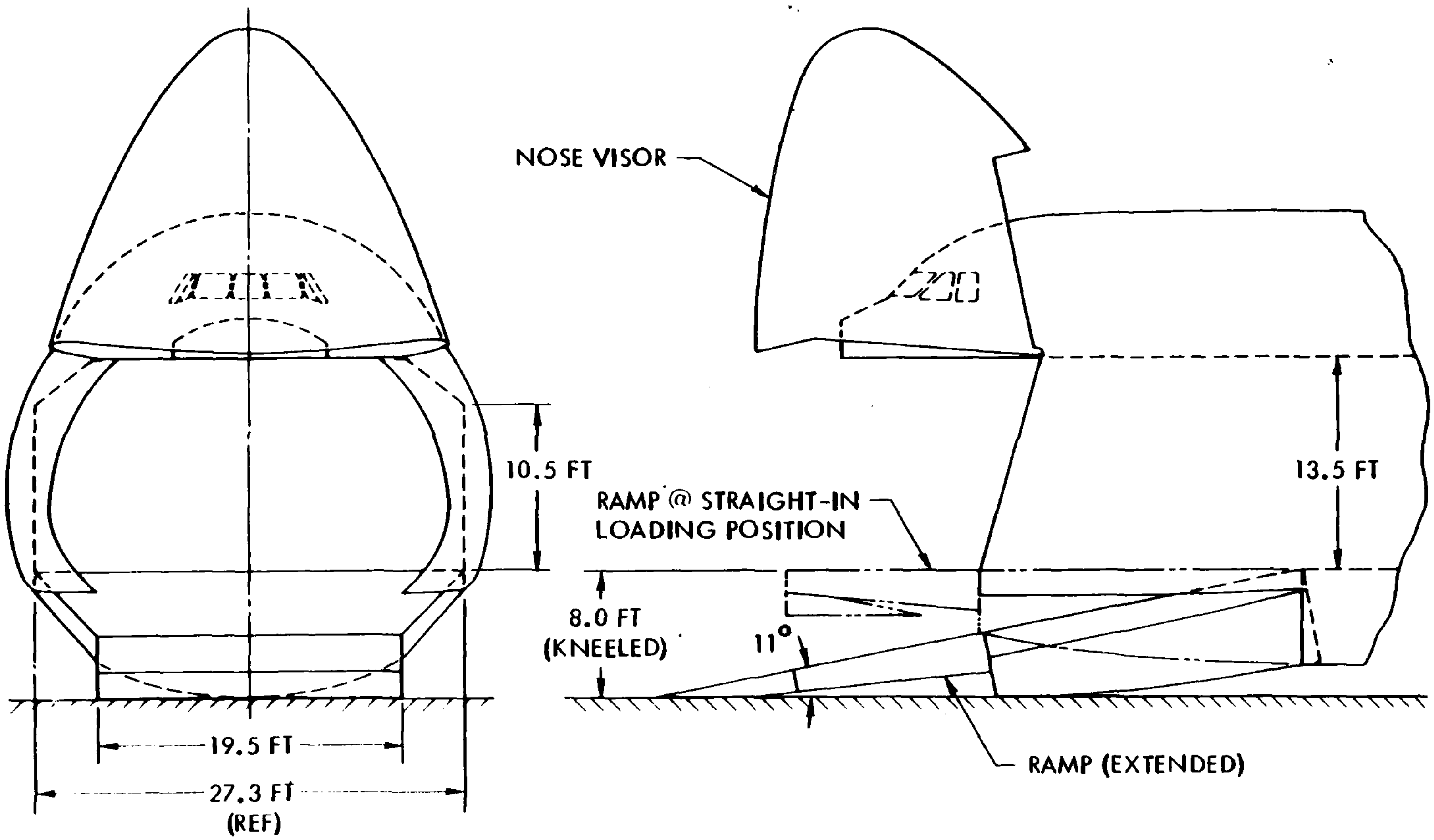


Figure A-3. Baseline Aircraft Forward Fuselage Arrangement Showing Front Aperture and Ramp

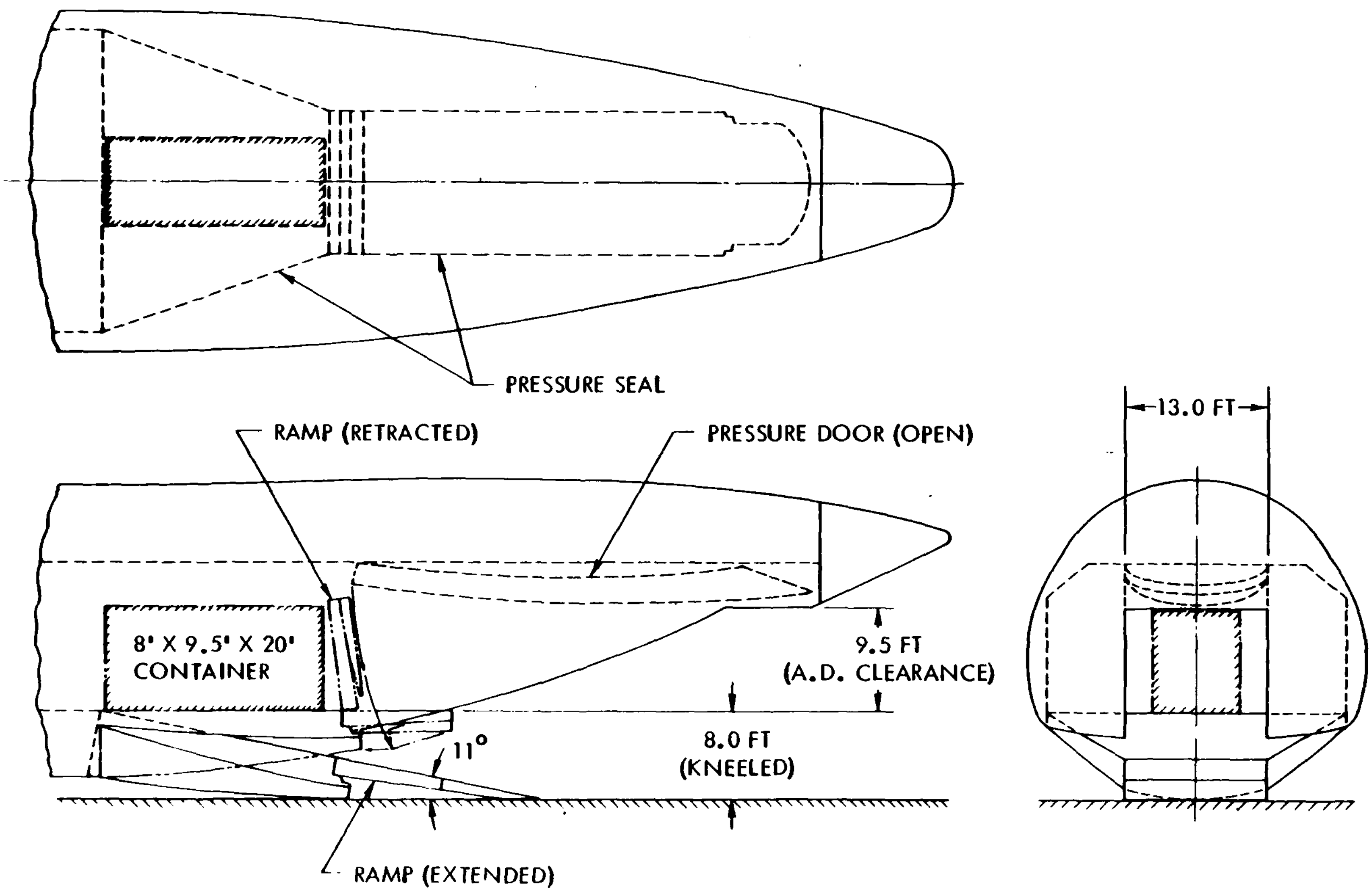


Figure A-4. Baseline Aircraft Aft Fuselage Arrangement Showing Rear Aperture and Ramp

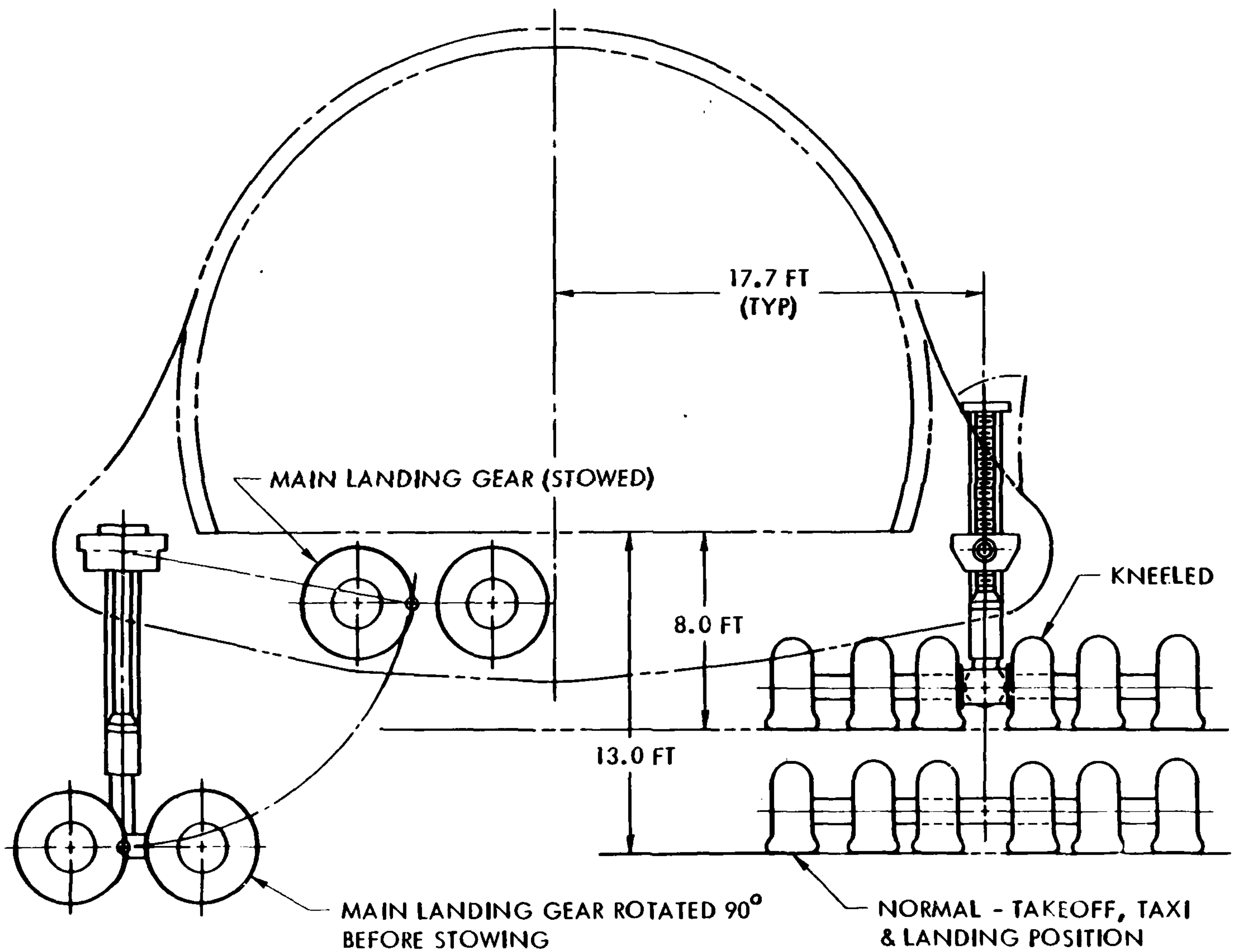


Figure A-5. Baseline Aircraft Main Landing Gear Arrangement

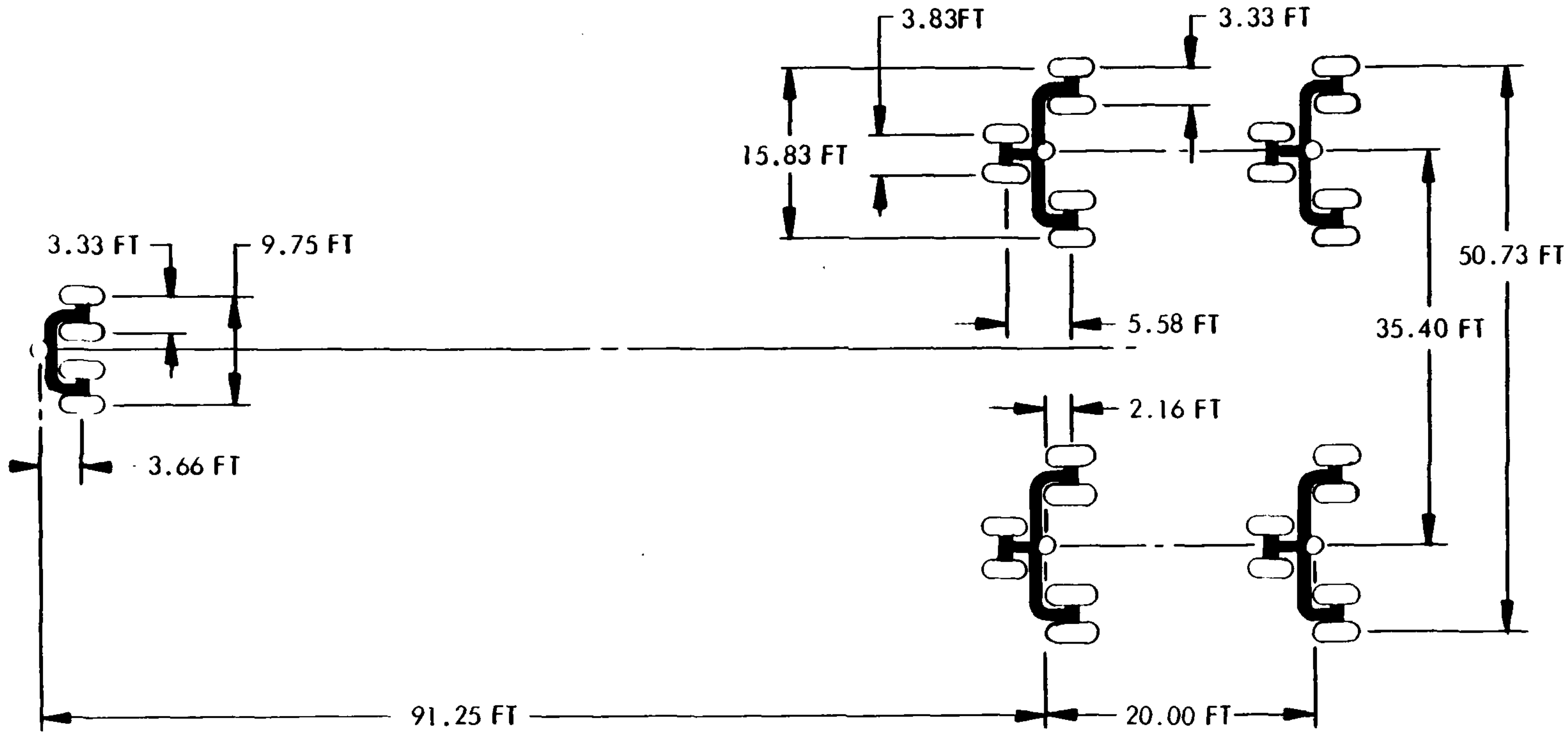


Figure A-6. Baseline Aircraft Landing Gear Footprint

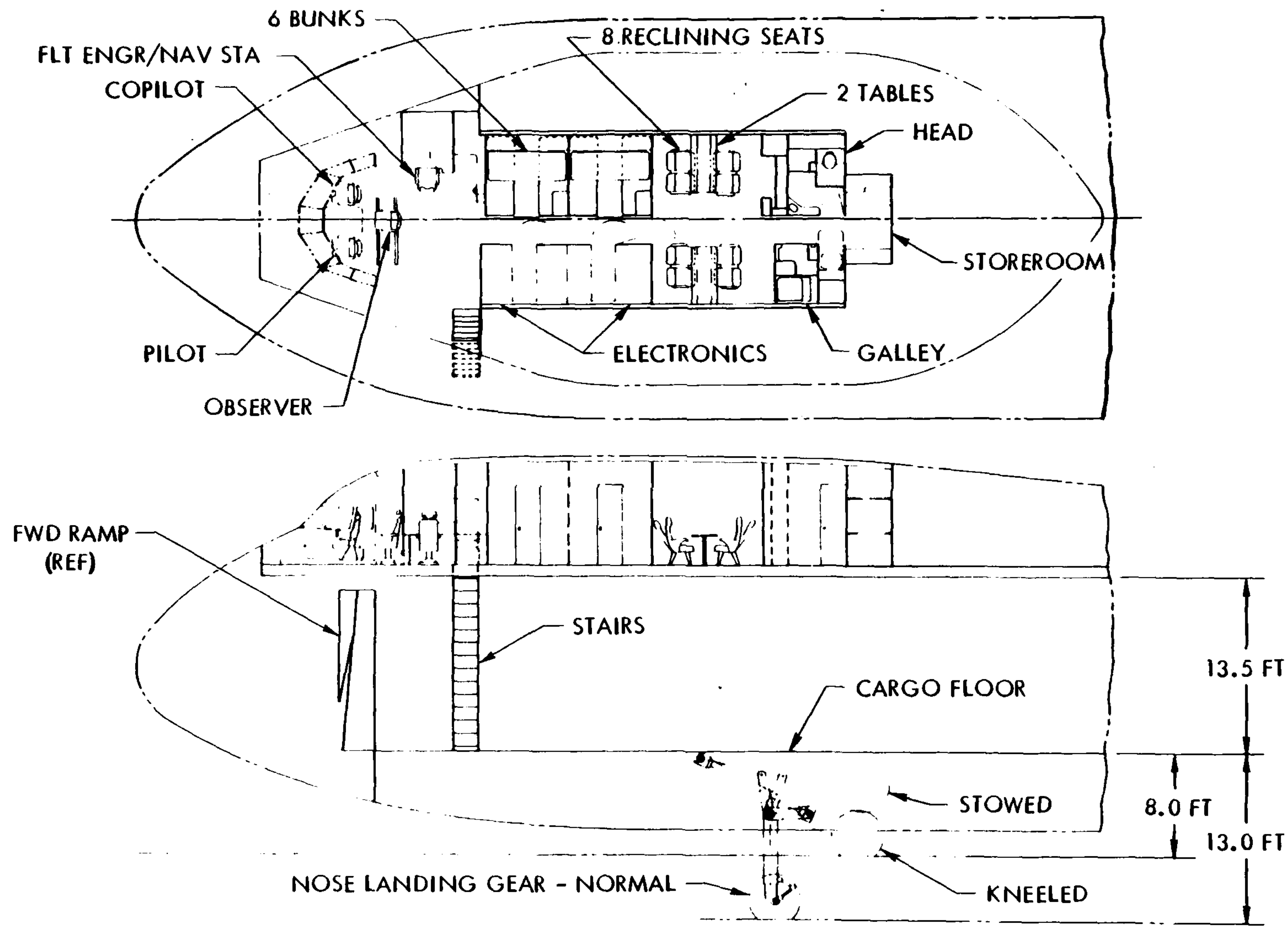
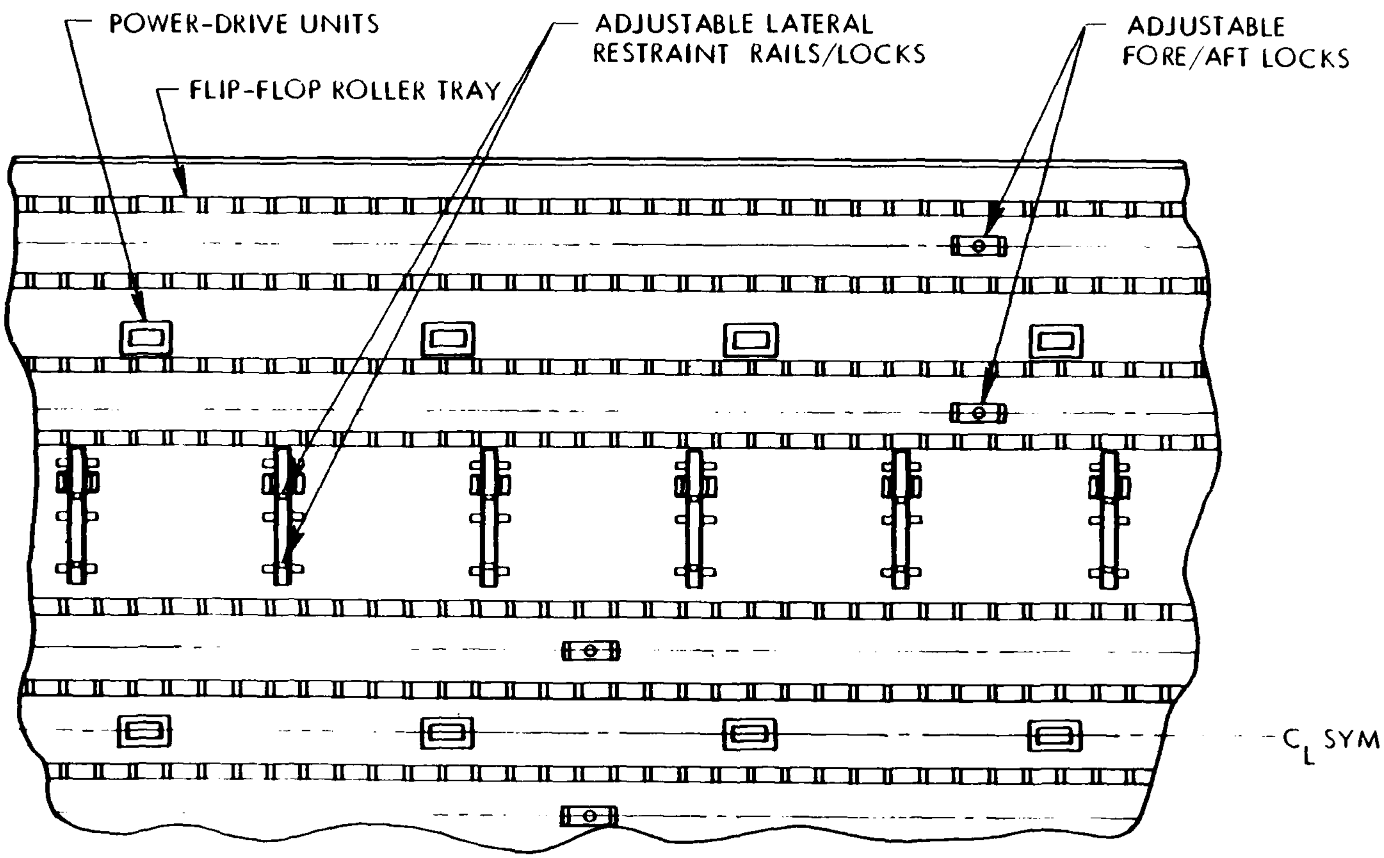


Figure A-7. Baseline Aircraft Forward Fuselage Arrangement Showing Flight Station and Relief-Crew Compartment



TOP VIEW OF FLOOR SECTION

Figure A-8a. Baseline Aircraft Cargo Accommodation System

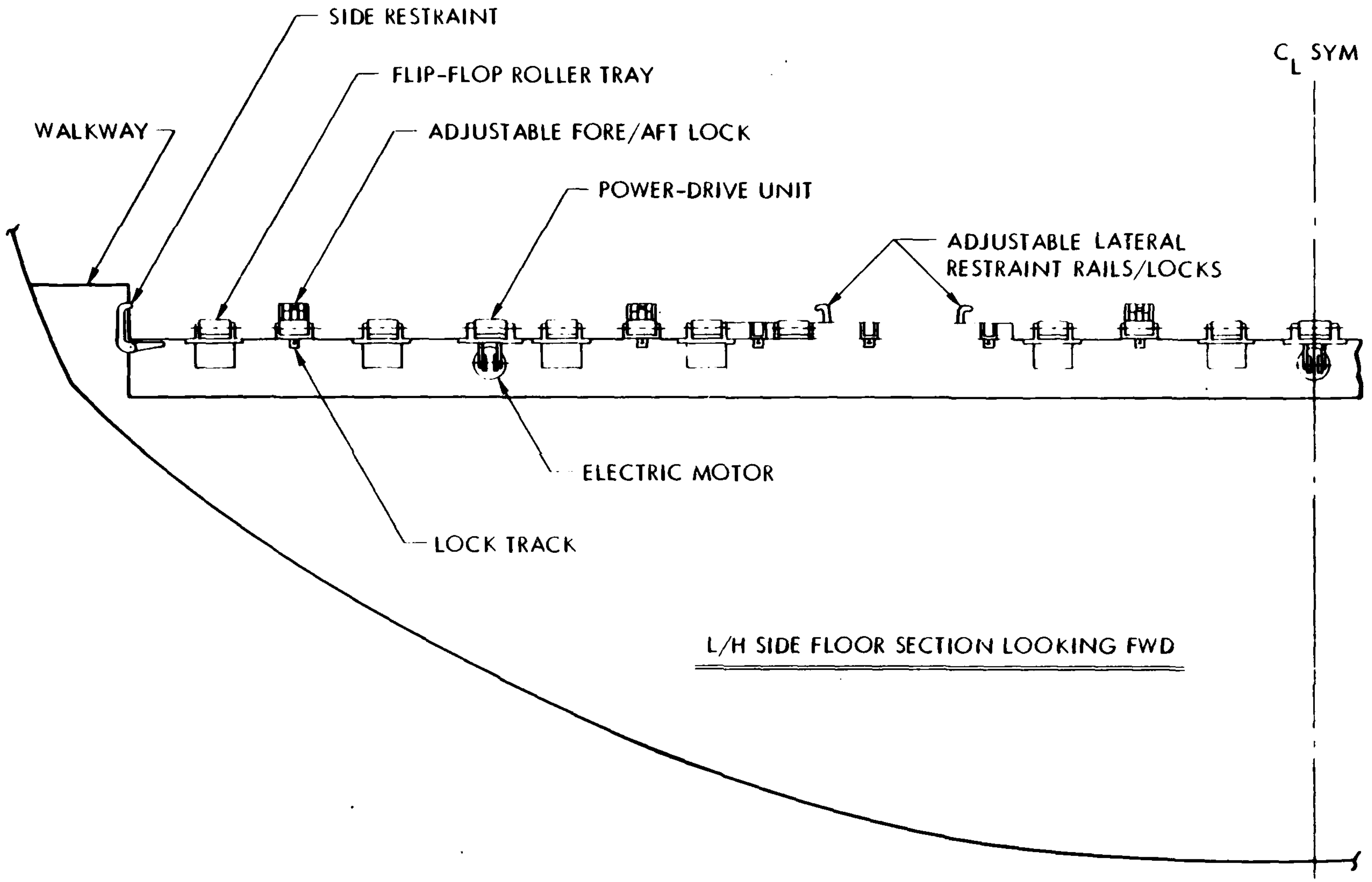


Figure A-8b. Baseline Aircraft Cargo Accommodation System

- The roller trays be flip-flopped so that the rollers reside in the channels as shown in Figure A-8b
- The fore/aft locks and lateral restraint rails/locks be removed from their lock tracks and stowed
- The power-drive units be removed and stowed and cover-plates be installed at each position

Stowage areas can be provided beneath the walkways located in the fuselage cheek area, as shown in Figure A-8b.

Finally, Figure A-9 illustrates the fuselage of the baseline aircraft with a tanker kit installed. Observe that either the advanced aerial refueling boom or the current boom used on the KC-135A can be accommodated. The hose and drogue installation is omitted from Figure A-9 for clarity. It is located beneath the deck of the operator's station on the left-hand side of the aircraft. The tanker kit depicted in Figure A-9 was adapted from a design developed for the C-5A. (Ref A-1)

TECHNOLOGY LEVEL

The baseline aircraft configuration has been developed based on the incorporation of the following advanced technologies:

- Aerodynamics
  - Supercritical airfoils
  - Advanced computational methods
- Structures
  - Composites in secondary structure
  - Composites in primary structure
- Propulsion (based on Pratt & Whitney STF477 study engine)
  - Improved component efficiency
  - Advanced structural technology
- Stability and Control
  - Relaxed static stability

Each of these areas will be discussed in the following paragraphs in terms of a further description of the technology, its estimated benefit relative to current technology, and the expected date of technological maturity.

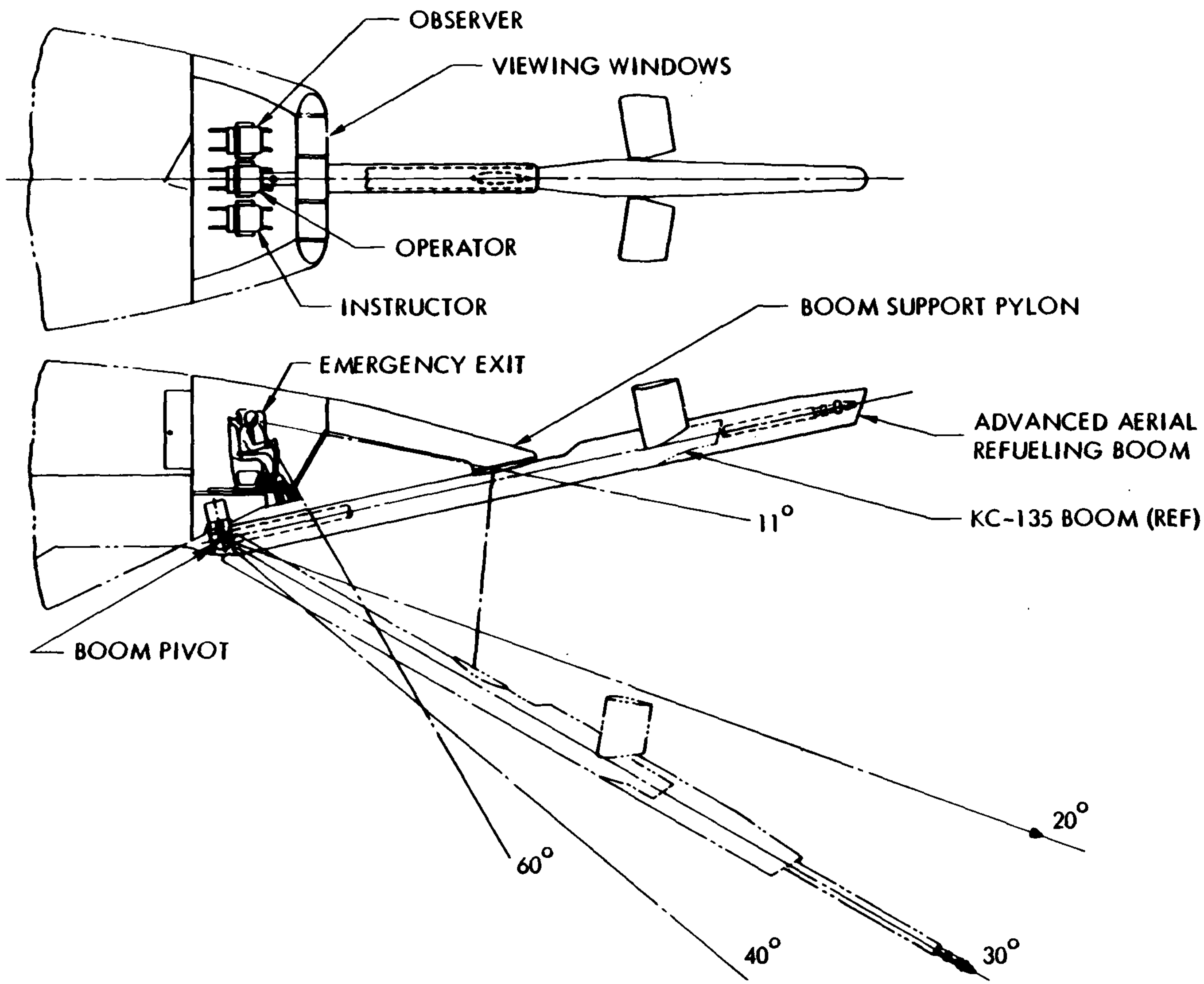


Figure A-9. Baseline Aircraft Aft Fuselage Arrangement with Tanker Kit Installed

AERODYNAMICS

Application of supercritical airfoil technology, as opposed to the conventional airfoil concepts exemplified by the aircraft of the late 1960s, provides greater design flexibility through tradeoffs between airfoil performance and design constraints. Improved performance of supercritical airfoils results from the use of increased aft camber to reduce upper surface velocities in the crest region. High aft camber increases the lift contribution from the lower surface, which for a given total lift, reduces the angle of attack and upper surface lift. Additionally, a relatively flat upper surface contour is maintained in the supercritical region so that the shock formation will be somewhat further aft than on conventional airfoils. A larger supercritical flow region develops and is terminated by a weaker shock which results in a higher lift-to-drag ratio (L/D) for a given level of shock strength. For a given airfoil lift coefficient, the combination of reduced upper surface velocities and weaker shock strength is manifested as an increase in drag divergence Mach number and, consequently, a higher cruise speed.

During configuration design and development, the improved aerodynamic capabilities of the supercritical airfoil can be used in a number of ways, depending upon the design requirements. For high-speed design, supercritical wing technology provides a higher cruise speed for a given wing sweep and thickness. Alternatively, where cruise speed requirements are subordinate, supercritical technology allows a thicker wing section and/or reduced wing sweep, resulting in lower wing weights.

At the design Mach number, lift coefficient, sweep angle, and aspect ratio of the C-5A, a supercritical design would allow an increase in wing thickness ratio from 11 percent to 14.5 or 15 percent, which translates to a reduction in wing weight of about 10 percent. For the same thickness ratio and lift coefficient, an increase of 2 to 2.5 percent in cruise Mach number can be expected while reducing the wing sweep angle by 5 degrees.

Transonic aircraft design is complicated by the mixed nature of the flow field and the frequent presence of shock waves. The flow complexity has hampered development of design and analysis methods because of the need for a non-

linear problem formulation. Consequently, the designer has had to rely almost exclusively on the wind tunnel to design recent transonic aircraft. Drawbacks of purely experimental design, coupled with recent advances and expected future advances in the area of computational fluid dynamics have resulted in the development of, and increased reliance upon, new computational methods. In particular, the development of 2-D methods, which has naturally outpaced that for 3-D methods, has progressed to the extent that 2-D methods are now used extensively to design advanced-technology airfoils. Significant strides are now being made in the development of 3-D transonic codes, initially restricted to isolated wings and inviscid flow. However, these are being expended to include interactions between the wing and finite-length bodies.

Design optimization schemes, utilizing numerical methods combined with these aerodynamic analysis codes, should lead to improved aerodynamic performance. For example, component interference drag optimization based on advanced computational methods should provide drag reductions on the order of 4 to 5 percent relative to current transport levels. Additional benefits are expected from the use of numerical solutions of the Navier-Stokes equations to derive separation-free flows for configurations operating at high cruise lift coefficients.

STRUCTURES

The baseline aircraft incorporates graphite epoxy and/or boron epoxy in both the primary and secondary structure. Graphite epoxy and boron epoxy provide an increase in strength and stiffness with a lower density compared to all aluminum designs. The material is made up of layers of continuous fibers in an epoxy matrix which allows the structure to be tailored (by properly orienting the fibers) for the loads it will experience. The use of these materials can result in weight reductions of 20 to 40 percent depending on cost constraints. The assumptions on structures technology in this study are based on the success of current and projected development programs, with a technology readiness data consistent with the 1995 Initial Operational Capability (IOC) of the ACMA. (A technology readiness date is defined as the date at which sufficient data exists for company management to make a commitment on using the advanced material in the design of a future airframe

component.) Production readiness cannot be predicted as accurately because of the additional factors of facilities, material availability and customer acceptance. These difficulties are beyond the scope of this study.

Table A-1 presents the group weight statement for the baseline aircraft. As a point of reference, the empty weight fraction for the baseline aircraft is 0.38 compared to 0.46 for the C-5A. Of course, not all of this improvement can be attributed to structural technology since each of the other technologies also influences aircraft empty weight.

PROPULSION

The Pratt & Whitney STF477 advanced technology turbofan engine was initially described in fuel conservation studies sponsored by NASA in 1974-76. The study engine incorporates new fan, compressor, combustor, and turbine technology to give improved component efficiencies and lower fuel consumption. The STF477 is planned to have higher-work compressor stages to reduce the number necessary to attain the target pressure ratio, and the fan and turbines will likewise be designed to minimize size, weight, and parts count. Also, new structural technology will be incorporated to further reduce size and weight. Active clearance control is expected to be incorporated in the compressor and turbine to improve performance and minimize deterioration.

Pratt & Whitney originally stated that a vigorous technology development program carried on through 1985 would be required to support a 1990+ IOC.

Presently the target IOC for a STF 477 technology-level engine is 1998, with penalties in fuel consumption and engine weight for earlier dates. Exactly what technology will be available in the mid-1990s for a long-life, high-reliability, transport-type engine cannot be predicted with a high degree of certainty at this time, especially for engines in the 75,000 lb-thrust category required for the baseline ACMA. Pratt & Whitney indicates, however that technical breakthroughs are not required for an STF477. Indeed, the NASA sponsored Energy Efficient Engine, so called "E"-cubed (E^3), studies and test programs to be conducted by both Pratt & Whitney and General Electric during the late 70s and early 80s will provide substantial technology advancements

TABLE A-1
GROUP WEIGHT SUMMARY FOR THE BASELINE AIRCRAFT

WEIGHT GROUP	WEIGHT (LB)
Wing	156,482
Horizontal Tail	7,108
Vertical Tail	5,248
Fuselage	183,069
Nose Landing Gear	6,292
Main Landing Gear	42,108
Nacelle	4,970
Pylon	7,298
Engines	54,744
Fuel System	6,192
Thrust Reversers	9,197
Miscellaneous	3,470
Auxiliary Power System	1,543
Surface Controls	10,538
Instruments	1,755
Hydraulics and Pneumatics	4,911
Electrical	4,524
Avionics	2,400
Furnishings	8,238
Air Conditioning and Anti-Ice	6,247
Auxiliary Gear and Equipment	254
Weight Empty	(526,585)
Operating Equipment	16,754
Operating Empty Weight	(543,339)
Payload	495,000
Zero Fuel Weight	(1,038,339)
Fuel	332,138
Gross Weight	(1,370,477)
AMPR Weight	444,480

that can be applied to the STF477. We believe, therefore, that STF477-level technology can be available for a 1995 ACMA with little technical risk, contingent on the continuance of E^3 and other advanced-technology programs. Furthermore, the performance characteristics of the STF477 may well be available in engines for combat aircraft in the time frame of interest; if so, the real challenge will be to obtain this performance along with the long life and high reliability required for a transport engine.

Also of significance is the fact that the engine manufacturers are not currently addressing the 75,000 lb thrust and larger engines required in the present effort. Presuming that required manufacturing machinery capacities are the same as those presently available, or that new machinery will be acquired, there is no reason to believe that STF477-level technology cannot be applied to the larger engines.

Basic characteristics of the STF477, along with the E^3 and the TF39 engine currently used in the C-5A, are listed in Table A-2. Both the STF477 and E^3 have been scaled to the thrust of the TF39 for this comparison, rather than the thrust level of the baseline aircraft because no scaling data are available for the TF39. Note that the scaled STF477 is lighter and smaller than the TF39. Also, an improved altitude thrust lapse and cruise SFC are apparent. Because the TF39 was tailored to the long-range C-5A, minimum fuel consumption was emphasized in its design. What appears to be a modest 7 percent SFC improvement in the STF477 is a significant advancement when coupled with engine hardware improvements and other performance improvements. From the standpoint of advantages to the aircraft, the STF477 advancements should be quite significant.

To summarize, transport aircraft engine development programs by all manufacturers usually follow an orderly progression to obtain more thrust with improved fuel consumption from smaller, lighter engines, with longer life, more reliable, and easier to maintain hardware. Transport engines are sometimes derived from advanced-technology engines developed for combat aircraft. Occasionally, there are examples of emphasis on a specific performance characteristic, such as fuel consumption on the TF39, for an engine tailored for a specific aircraft or purpose. Sizing is always an uncertainty in the concept-

TABLE A-2

STF477, TF39, AND E^3 ENGINE CHARACTERISTICS

PARAMETER	UNITS	STF477[a]	TF39-GE-1	E^3
IOC	-	1998	1971	1990+[b]
Rated thrust, SL, static	lb	41100[c]	41100[d]	41100[c]
TSFC at rated thrust[e]	lb/lb/hr	.280	.308	.315
Fan pressure ratio	-	1.7	1.45	1.74
Overall pressure ratio	-	45	21.8	38.6
Bypass ratio	-	8	7.8	6.55
Inlet airflow	lb/sec	1610	1536	1508
Max turbine gas temperature	°F	2600[f]	2350[g]	2550[f]
Max case diameter	in	94.1	97	88
Case length	in	131.6	191	121
Dry weight	lb	6380[h]	7400[i]	7033[h]
Stages[j]	-	1-3-10-2-5	1.5-0-16-2-6	1-4-10-1-4
Altitude performance, max cruise M = 0.77, ISA, uninstalled				
Thrust	lb	10125	8612[k]	9864
TSFC	lb/lb/hr	.532	.571	.561

Notes:

(a) Scaled from 26550 lb thrust
(b) Test engine running in 1985
(c) Flat rated to 84°F
(d) Flat rated to 89.5°F
(e) At 59°F
(f) Combustor exit
(g) Turbine inlet temperature
(h) Includes containment and sound treatment
(i) No fan containment or sound treatment
(j) Fan, booster, compressor, high-pressure turbine, low-pressure turbine
(k) 90% max continuous

development phase as is the case in the 1990+ engine for the ACMA. As noted earlier, the 75,000 lb-thrust class engines forseen for the baseline ACMA are not being seriously considered in current engine manufacturer studies; such activity must be initiated soon if this class engine is to be available. Although specific, engine-manufacturer sanctioned scaling data for 1990+ technology engines in the ACMA thrust class are not available, existing extrapolations should yield acceptable results for the present study.

STABILITY AND CONTROL

Design criteria for sizing the directional, lateral, and longitudinal control surfaces of the baseline aircraft are based on the guidelines of Military Specification MIL-F-8785B. The horizontal tail surface, however, has been sized in accordance with relaxed-static-stability technology. Surface area requirements are derived from the control-power considerations associated with takeoff rotation, trim at the forward center-of-gravity limit, and engine-out characteristics. Relaxed-static-stability technology can reduce the horizontal tail surface area by as much as 40 percent; however, the corresponding reduction in aircraft gross weight approaches only about one percent for the class of aircraft represented by the baseline. This technology is nearing maturity at present.

An automatic stability augmentation system based on active-controls technology is also incorporated in the baseline aircraft. However, no attempt has been made to do the detail design or to provide the control laws for this system, since such detail is beyond the scope of the present effort.

PERFORMANCE CHARACTERISTICS

Figure A-10 presents the payload-range characteristics of the baseline aircraft. Note that these data reflect the use of military rules for estimating aircraft range performance.

Takeoff characteristics of the baseline aircraft are displayed in Figure A-11. Both critical field length (i.e., military rules) and FAR balanced field length (i.e., civil rules) are shown as a function of gross weight. Recall

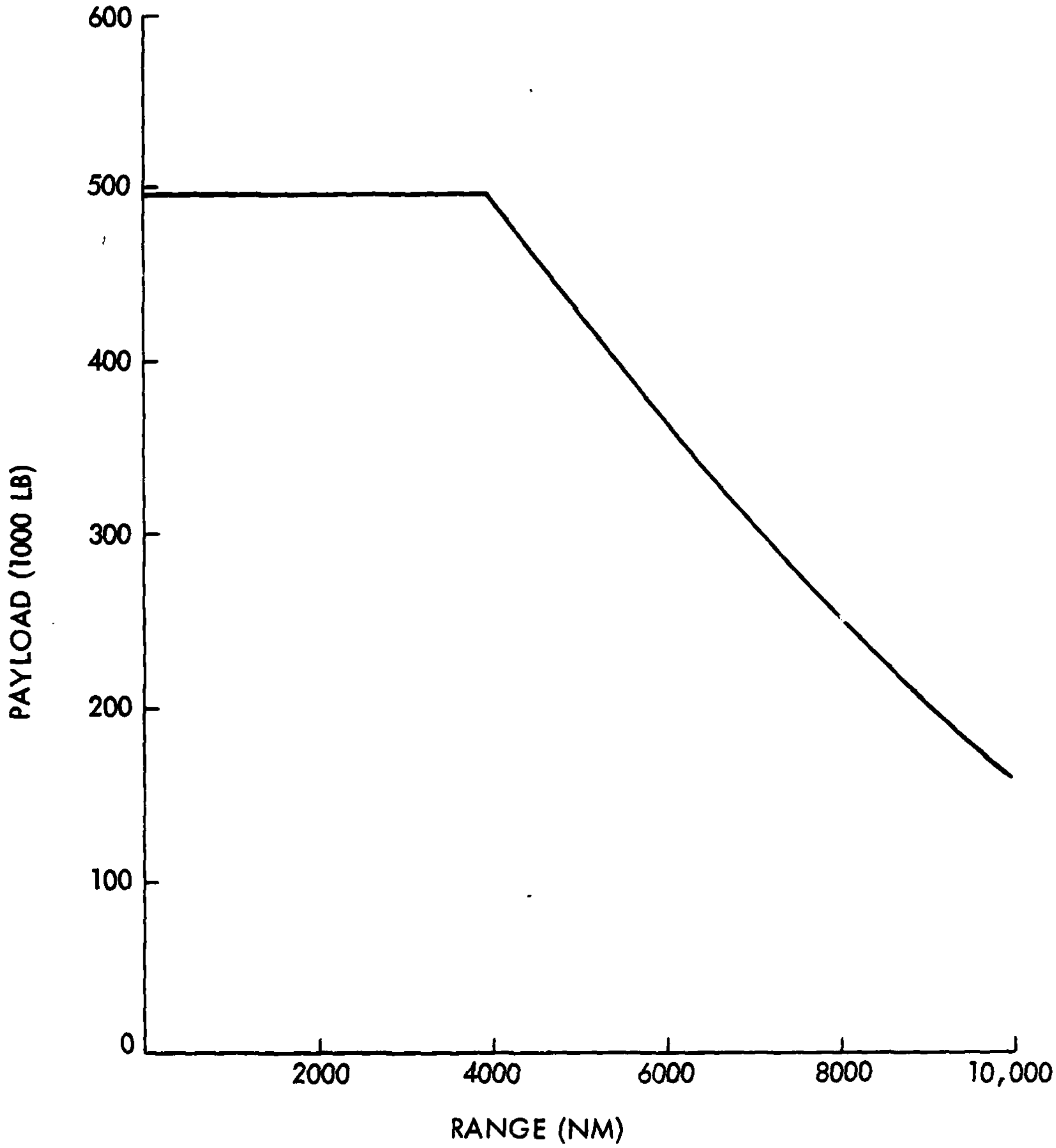


Figure A-10. Payload-Range Characteristics of the Baseline Aircraft -- Military Rules

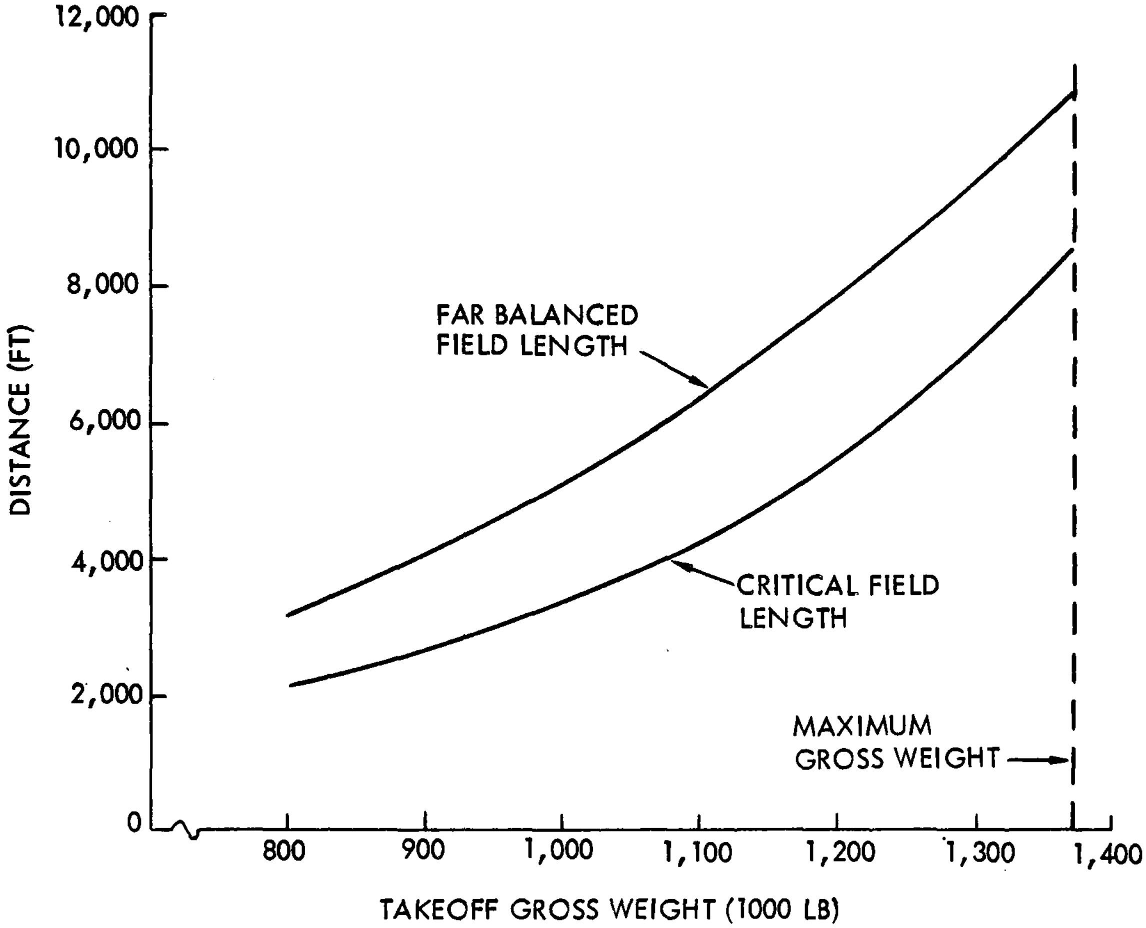


Figure A-11. Baseline Aircraft Takeoff Distance Characteristics

that the baseline aircraft was sized on the basis of a 9500 ft takeoff distance over 50 ft at maximum gross weight. Landing gear flotation characteristics of the baseline aircraft have a LCG II capability at maximum gross weight and an LCG III capability at its design landing weight.

Finally, Table A-3 presents a summary of the weight characteristics of the commercial and the tanker versions of the baseline aircraft. As noted in Volume II and III, the baseline aircraft is sized on the basis of its military configuration and is designated Model No. LGA-144-100. The commercial version, designated Model No. LGA-144-100C, deletes the items listed in Table A-3. All of these would, however, be installed as kits in the -100C, if activated in a CRAF role. Note the commercial payload is increased due to the removal of military equipment such that the takeoff gross weight of the civil and military versions are equal. Model No. LGA-144-100T is the tanker version of the aircraft. As discussed in Volume III, only organic military aircraft (i.e., the -100) are convertible to the tanker configuration. Note that the maximum gross weight (at 2.50g limit-load factor) is the same for all three versions of the baseline aircraft.

Table A-4 presents other pertinent design and performance data for the baseline aircraft.

TABLE A-3
SUMMARY OF WEIGHT CHANGES FOR COMMERCIAL AND TANKER VERSIONS OF THE BASELINE AIRCRAFT

ITEM	WEIGHT (LB) -100C	WEIGHT (LB) -100T
LGA-144-100 OPERATING EMPTY WEIGHT	543,339	543,339
RAMPS	-15,110	-
RELIEF-CREW FURNISHINGS	-700	-
CARGO WINCH	-340	-
LOADING STABILIZER STRUTS	-430	-
AERIAL REFUELING RECEPTACLE	-120	-
TANKER - KIT SCAR WEIGHT	-1,470[a]	-
TANKER KIT	-	+5,360
TIEDOWN EQUIPMENT	-7,420	-
TIEDOWN RINGS	-1,610	-
LOADMASTERS	-440	-[b]
OPERATING EMPTY WEIGHT	(515,699)	(548,699)
MAXIMUM PAYLOAD	522,640	0[c]
ZERO FUEL WEIGHT	(1,038,339)	(548,699)
FUEL	332,138	821,778
MAXIMUM GROSS WEIGHT	(1,370,477)	(1,370,477)

[a] Commercial versions are not convertible to tanker configuration

[b] At least one loadmaster replaced by boom operator

[c] Payload can be carried at the expense of fuel off-load when performing tanker/cargo missions

TABLE A-4
DESIGN AND PERFORMANCE DATA LGA-144-100

FUSELAGE GEOMETRY	
Length (ft)	320
Wetted Area (ft^2)	27,274
Pressure Volume (ft^3)	188,427
Cargo Compt L X W X H (ft)	245.3 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	10,376	1,203	1,113
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.49	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	330	74	37
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	79,529
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	495,000	522,640
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

REFERENCES

A-1. Lockheed-Georgia Co., "C-5B Advanced Tanker/Cargo Aircraft," April 1977.

APPENDIX B. DESIGN TOOLS

This appendix contains a brief description of two of the principal design tools utilized in the Design Options Study. These are: (1) a computer-graphics based aircraft design program known as GRADE (GRaphics for Advanced Design Engineers) and (2) a computerized aircraft sizing program known as GASP (Generalized Aircraft Sizing and Performance).

GRADE

Fuselage design was aided by the use of Lockheed's privately developed GRADE program. This design tool allows the precise definition of the fuselage surface that is necessary to show the results of subtle changes to the baseline shape.

The concept of GRADE is a three-dimensional, mathematical description of the surface of an airplane which can be manipulated by the designer to the desired configuration. The program has built-in safeguards to prevent changes which would result in improper surfaces. Consequently, cross sections anywhere on the fuselage can be defined, and parameters such as fuselage wetted area and pressurized volume are automatically calculated. Other design analysis tasks such as determination of forebody and aftbody drag, as well as trial layouts of the wing and tail surfaces to check computer sizing runs, are made easier and faster.

An example of the way GRADE was utilized is shown in Figures B-1 and B-2. The Group II baseline aftbody is shown in the first figure. The control points are shown as they would appear on the screen. The option to delete the aft aperture allows the aftbody to be revised as shown in Figure B-2. By manipulating the control points, the designer obtains a new three-dimensional shape which takes best advantage of the deletion of the aft door. Cross sections are checked for structural clearances and assist in the calculation of aftbody drag.

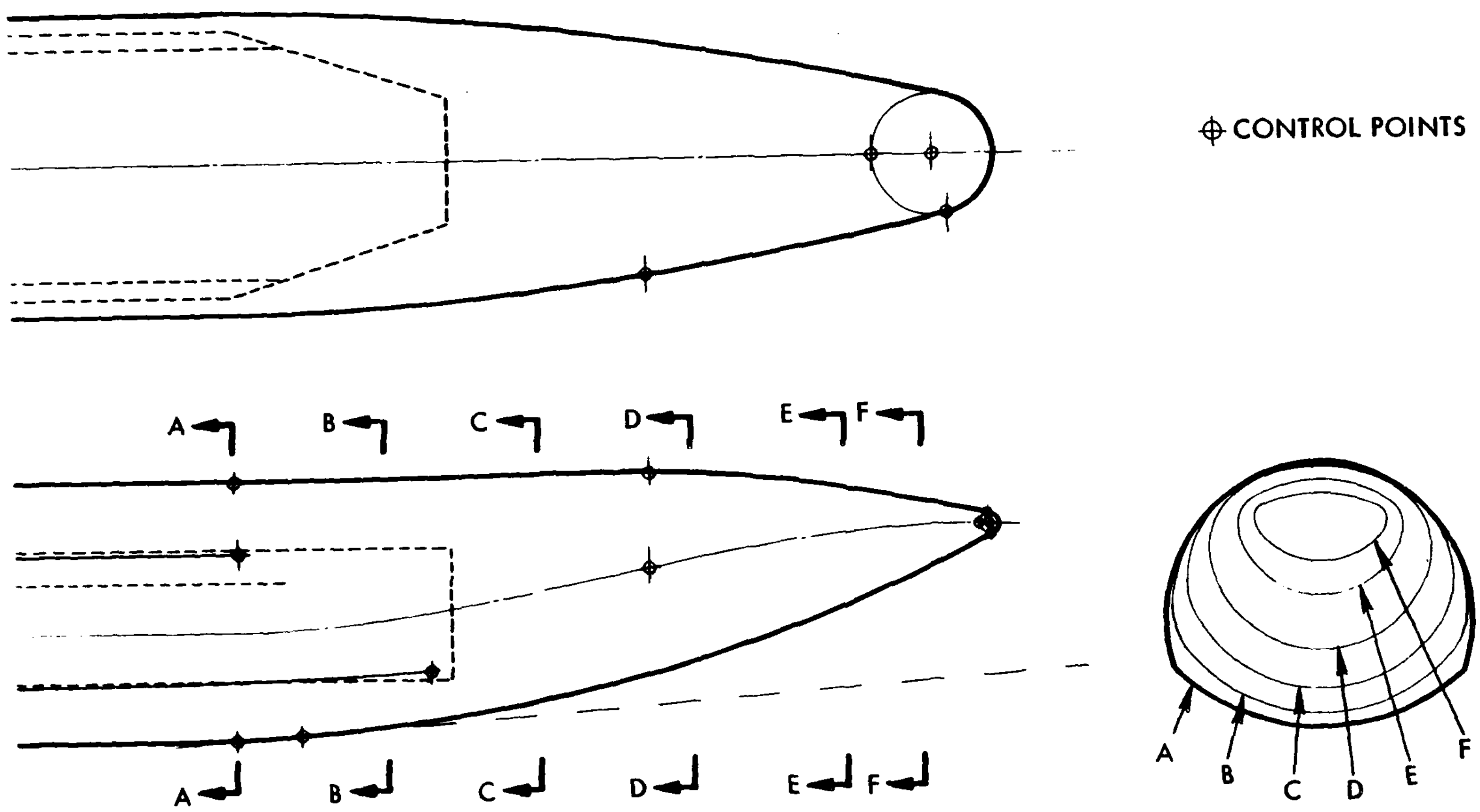


Figure B-1. Baseline Aftbody

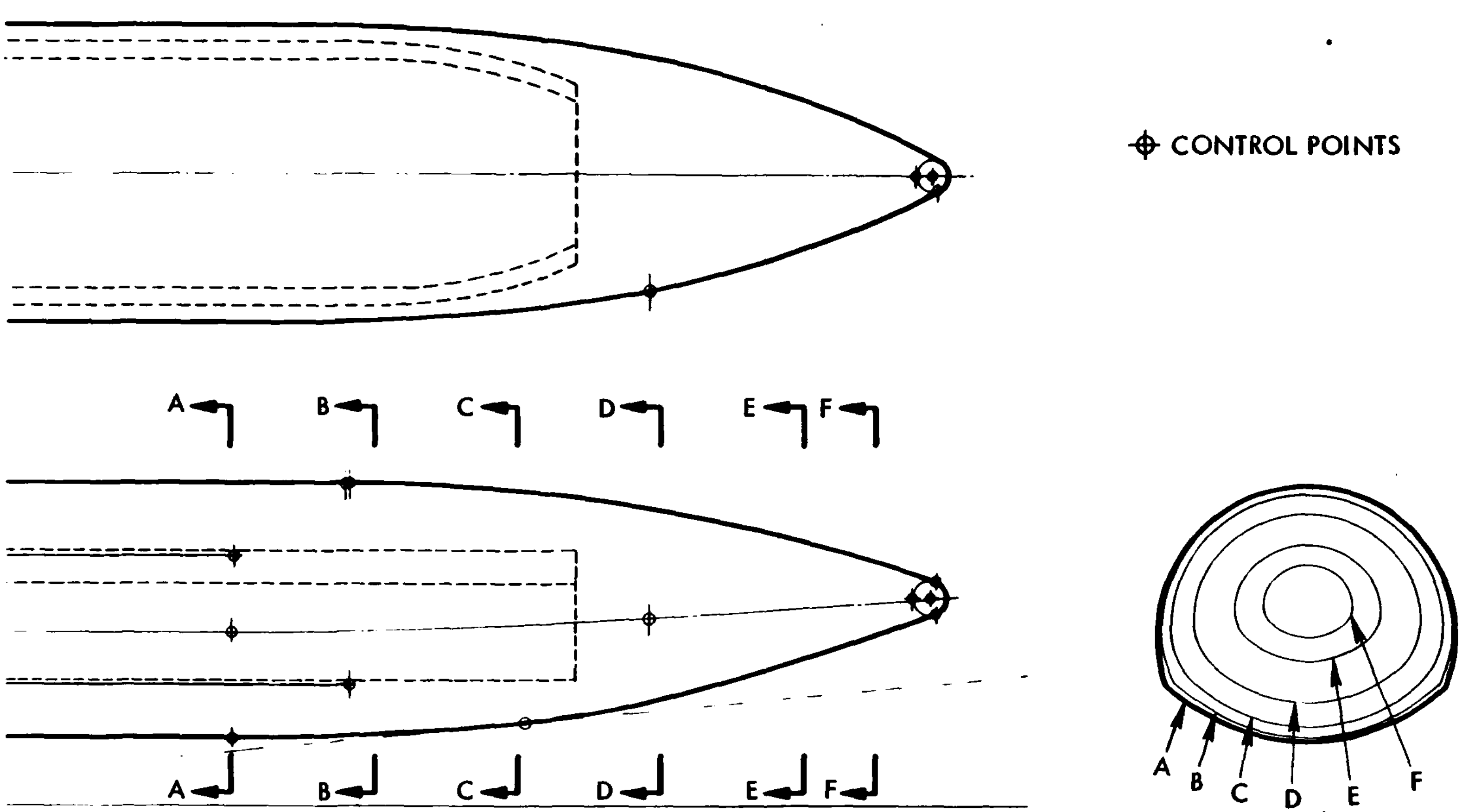


Figure B-2. Aftbody with No Rear Aperture

GASP

Aircraft sizing was accomplished by the use of Lockheed's privately developed GASP computer program, which accounts for the interaction of the various design constraints and technical disciplines involved in the aircraft design process. The GASP computer program methodology and sequence are outlined in Figure B-3. Configuration design data, aerodynamic parameters, propulsion system characteristics, and the defined mission parameters are primary input data.

The GASP program is designed to calculate drag coefficients and weight on a component basis, integrate the results into complete aircraft drag and weight, select the propulsion system size by matching (or mismatching to optimize the aircraft for a given field length) cruise thrust requirements, determine the aircraft sized for the mission, and iterate the process until the defined mission parameters are satisfied. The GASP program has sufficient flexibility to permit the use of adjusting factors representing changes in the level of technology for various technology performance areas such as airfoil and materials technology. These and all other technology areas were fixed throughout this effort at a level consistent with an early-to-mid 1990s IOC.

Aerodynamics

The aerodynamic methodology and basic technology for this aircraft design study evolved from many previous similar studies. Lockheed aircraft development programs, such as the C-130, C-141, C-5, L-1011, and JetStar provide both substantial experience for developing and refining new methodology and practical data for substantiating the validity of the analytical techniques. Aerodynamic design includes the following functions: (1) preparation of generalized aerodynamic design and trade-off data for use in aircraft parametric analysis, (2) aerodynamic support of other technical disciplines, and (3) aerodynamic design and evaluation of selected design points at various stages of the study. This study used the basic aerodynamic design process illustrated in Figure B-4. The two principal aerodynamic design criteria for the wing design are spanwise loading and section pressure distributions. Within the process, iterative steps are required to satisfy these two criteria

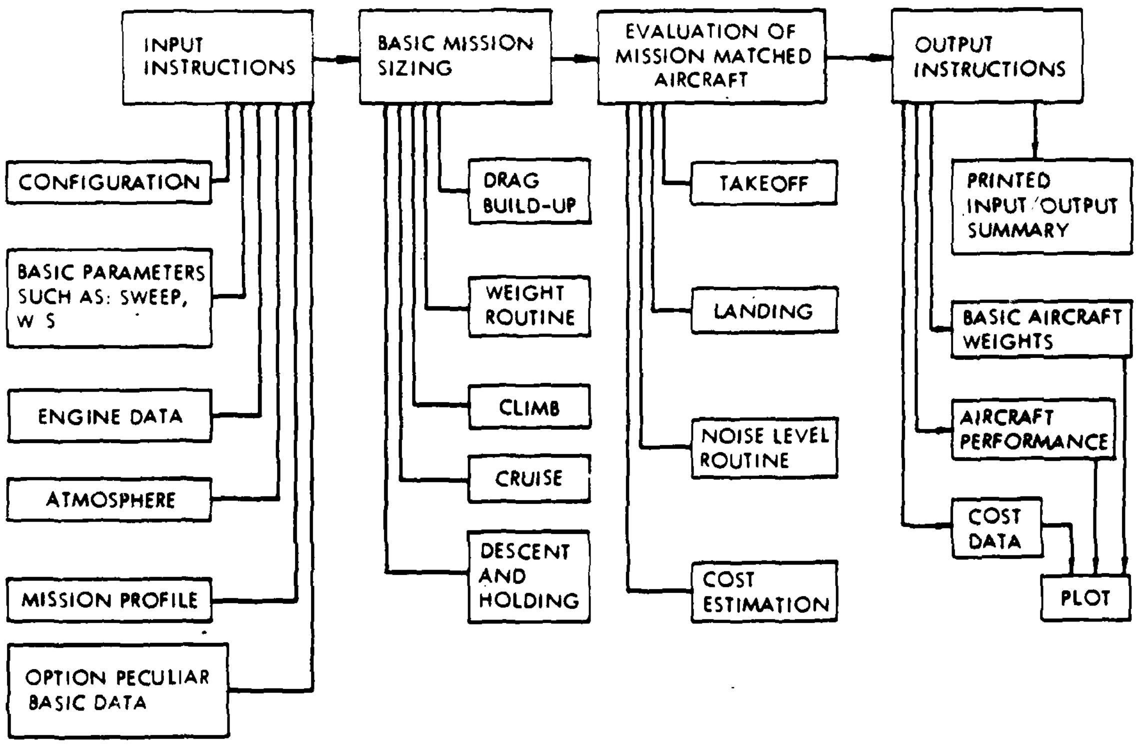


Figure B-3. Generalized Aircraft Sizing Program

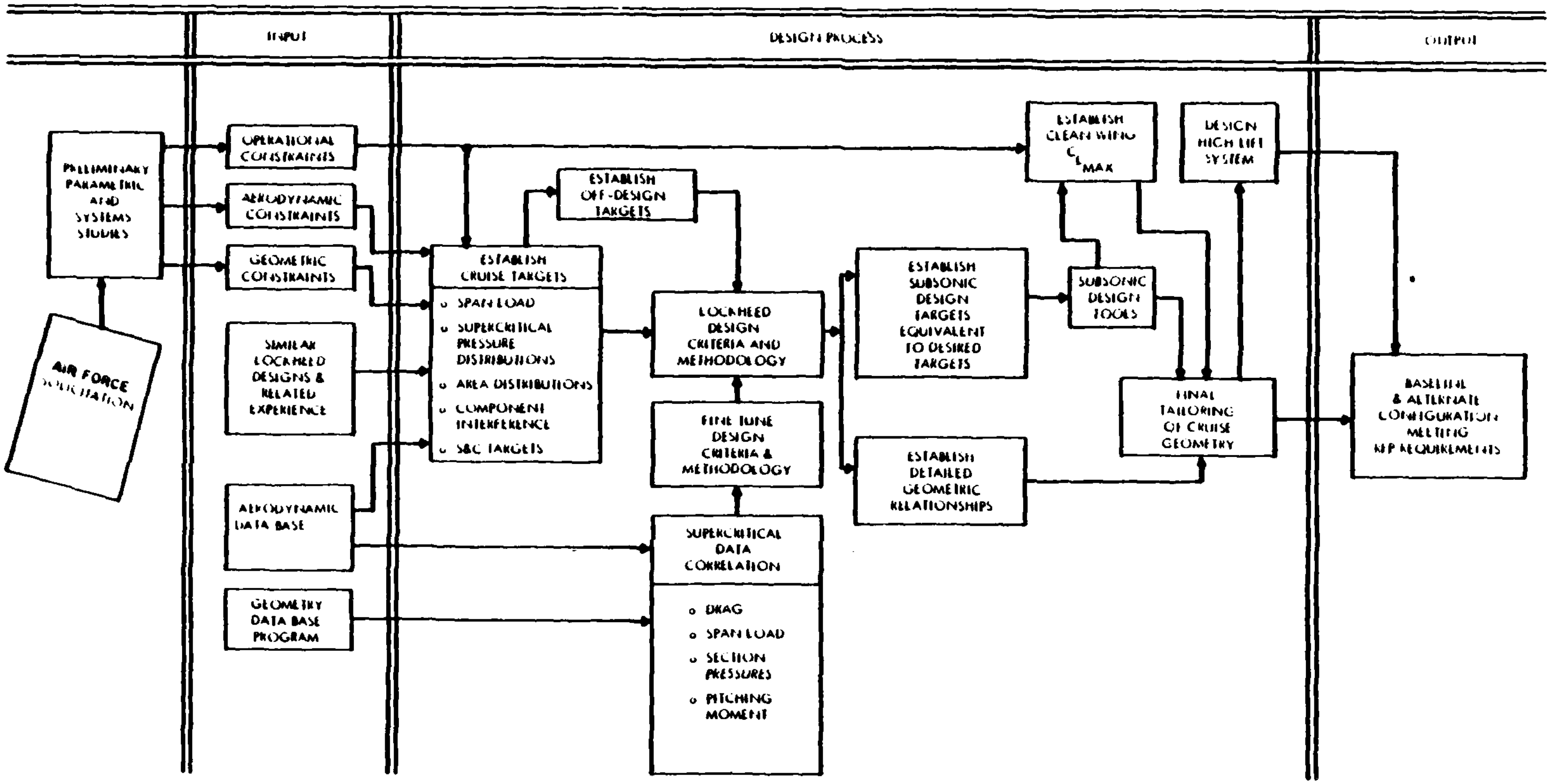


Figure B-4. Aerodynamic Design Process

as well as off-design and low-speed objectives. Using the basic elements of this process, which is explained further in Reference B-1, aerodynamic design was carried out in sufficient detail to validate performance estimates of the aircraft designs.

The equation for calculation of aircraft drag in the aerodynamic design process is expressed as:

$$C_D = \sum C_{D_O} + \Delta C_{D_{COMP}} + \Delta C_{D_I} + \Delta C_{D_{INT}} + \Delta C_{D_{ROUGH}} + \Delta C_{D_{TRIM}} + \Delta C_{D_{MISC}}$$

The zero-lift drag of each component, C_{D_O}, is estimated by determining the skin friction drag coefficient, corrected for form factor at the appropriate flight Reynolds number. A correction to account for the variation of the wing profile drag, ΔC_{D_P}, from the design values due to either Mach number or lift coefficient such as those shown in Figure B-5 is included in the drag build-up. A compressibility drag increment, $\Delta C_{D_{COMP}}$, which is a function of the design Mach number is also included; $\Delta C_{D_{COMP}}$ data which have been assembled from several advanced technology wing-body configurations are shown on Figure B-6. Completion of the drag polar build-up is achieved by adding the induced drag, ΔC_{D_I}, and the drag coefficient allowances for interference, surface roughness, and trim, $\Delta C_{D_{INT}}$, $\Delta C_{D_{ROUGH}}$, and $\Delta C_{D_{TRIM}}$, respectively. Where necessary, a miscellaneous drag increment, $\Delta C_{D_{MISC}}$, is included to account for items such as flap tracks and landing gear fairings.

Wing thickness-to-chord (T/C) ratio is a function of cruise speed, lift coefficient, wing sweep, and aspect ratio at a given level of compressible drag coefficient. Data for thickness ratio relationships, typical of that used in this study, are shown on Figure B-7.

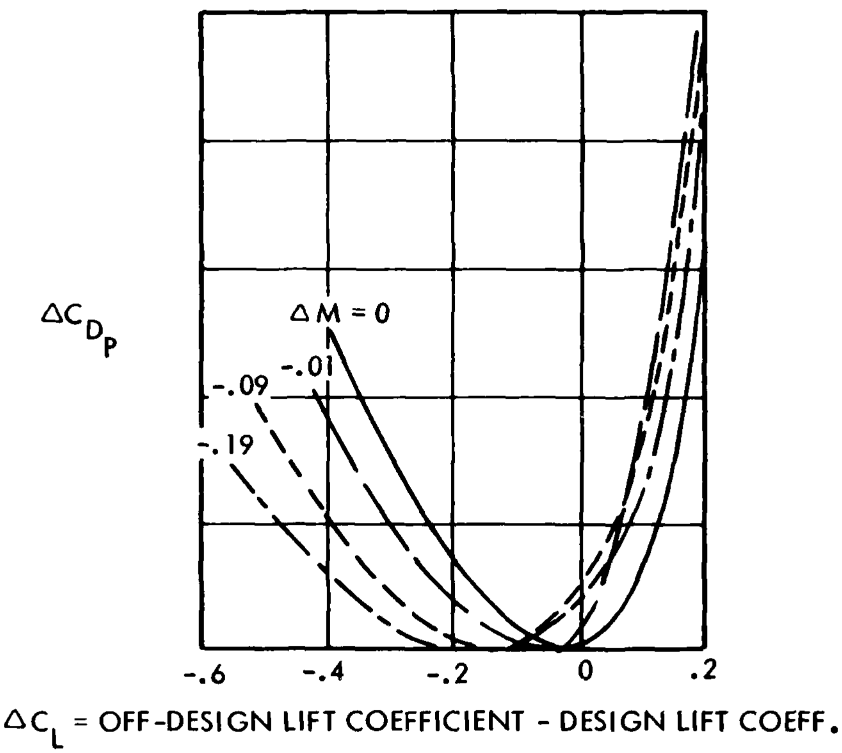


Figure B-5. Variations of Parasite Drag at Off-Design Lift Coefficient and Mach Number

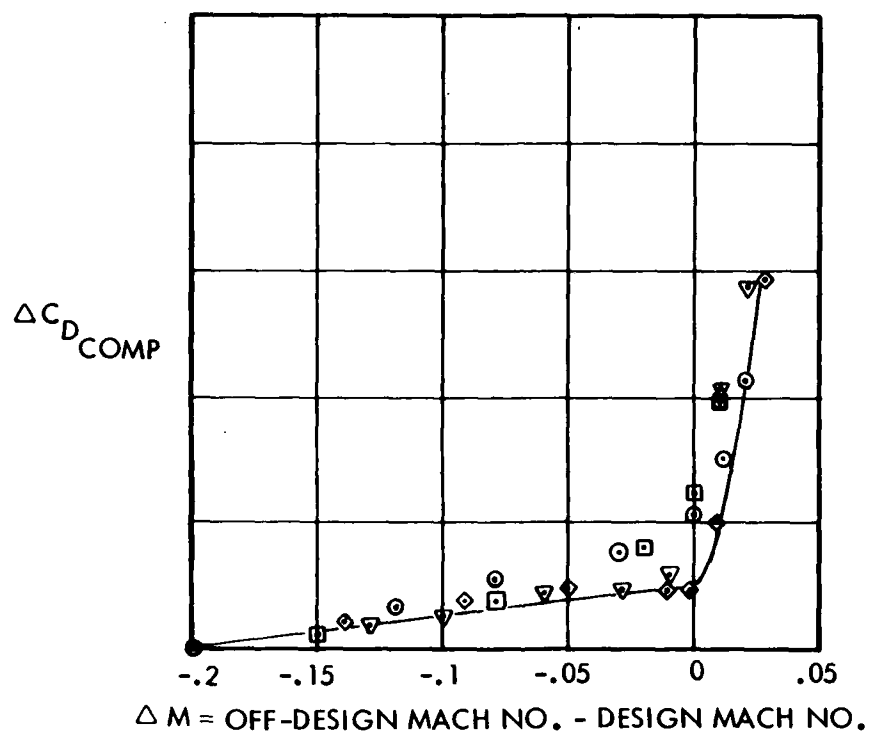


Figure B-6. Variations of Compressibility Drag at Off-Design Lift Coefficient and Mach Number

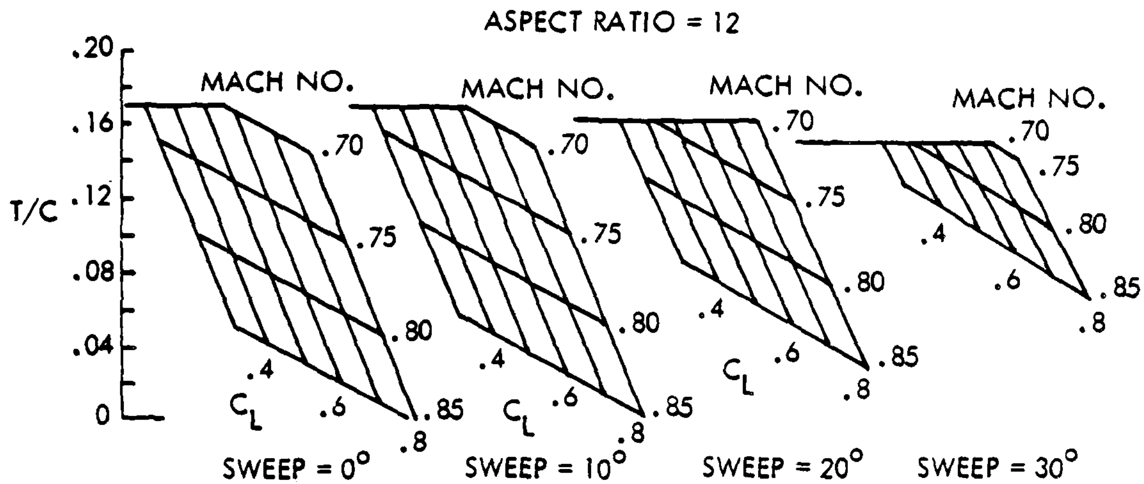


Figure B-7. Typical Supercritical Airfoil Wing Section Design Curves

REFERENCES

B-1. Bennett, J. A., et al., "A Computer Aided Wing-Body Aerodynamic Concept for Subsonic Vehicles for the 1970-1980 Period," AIAA Paper No. 69-1130, 1969.

APPENDIX C. DESCRIPTION OF GROUP I CONFIGURATIONS

This appendix describes in detail the Group I configurations. The Qualitative Assessment, Volume III, discusses the rationale for selecting the five design payloads shown below with their respective configuration identification.

Identification	Design Payload (lb)
LGA-144-100	495,000
LGA-144-111	450,000
LGA-144-112	405,000
LGA-144-113	360,000
LGA-144-114	315,000

The redesign of each configuration was accomplished simply by shortening the fuselage 20.25 feet for each payload decrease, keeping the forebody and aftbody shapes constant. The GASP program was used to resize the wing, engines, empennage, landing gear, and other components, as discussed in Appendix B.

Appendix A, "Description of the Baseline Aircraft," provides a complete definition of the LGA-144-100. All of the description of the baseline is applicable to the other four configurations in Group I with the exception of the fuselage cargo compartment and the changes brought about by the reoptimization of each configuration. Tables C-1 through C-15 list for the five configurations in Group I:

- o Design and Performance Data
- o Military Group Weight Statement
- o Summary of Weight Changes to Get Commercial Configuration

Figures C-1 and C-2 show a three view of the largest (-100) and smallest (-114) configurations in this group.

TABLE C-1
DESIGN AND PERFORMANCE DATA LGA-144-100

FUSELAGE GEOMETRY

Length (ft)	320
Wetted Area (ft^2)	27,274
Pressure Volume (ft^3)	188,427
Cargo Compt L X W X H (ft)	245.3 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	10,376	1,203	1,113
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.48	4.5	1.25
Taper	0.37	0.35	0.80
Span (ft)	330	74	37
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	79,529
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	495,000	522,640
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE C-2
GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-100

ITEM	POUNDS	
Wing		156,482
Horizontal Tail		7,108
Vertical Tail		5,248
Fuselage		183,069
Landing Gear		48,400
Nose	6,902	
Main	42,108	
Nacelles/Pylons		12,268
Nacelles	4,970	
Pylons	7,298	
Noise Treatment	0	
Propulsion System		73,603
Engines	54,744	
Thrust Reversers	9,197	
Fuel System	6,192	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		40,408
Auxiliary Power System	1,543	
Surface Controls	10,538	
Instruments	1,755	
Hydraulics and Pneumatics	4,911	
Electrical	4,524	
Avionics	2,400	
Furnishings	8,238	
Air-conditioning and Anti-ice	5,247	
Auxiliary Gear-Equipment	254	
Weight Empty		526,585
Operating Equipment		16,754
Operating Weight		543,339
Payload		495,000
Zero Fuel Weight		1,038,339
Fuel		332,138
Gross Weight		1,370,477
AMPR Weight		444,480

TABLE C-3
SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-100

LGA-144- 100	OPERATING WEIGHT	543,339
Delete:		
Ramp Extensions	15,110	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	7,420	
Tiedown Rings	1,610	
Loadmasters	440	
Total	27,640	
LGA-144- 100 C	OPERATING WEIGHT	515,699
Payload		522,640
ZERO FUEL WEIGHT		1,038,339
Fuel		332,138
GROSS WEIGHT		1,370,477

TABLE C-4

DESIGN AND PERFORMANCE DATA LGA-144-111

FUSELAGE GEOMETRY			
Length (ft)	299		
Wetted Area (ft^2)	25,426		
Pressure Volume (ft^3)	175,007		
Cargo Compt L x W x H (ft)	225.1 x 27.3 x 13.5		
Forward Aperture Width (ft)	19.5		
Aft Aperture Width (ft)	13.0		
SURFACE GEOMETRY	**WING**	**HORIZ**	**VERT**
Area (ft^2) (Basic)	9,418	1,091	1,033
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.50	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	314	70	36
Wing Loading (lb/ft^2)	129.35	-	-
ENGINE			
Thrust (Sea Level Static - lb)	72,146		
TSFC (Cruise lb/lb/hr)	0.594		
PERFORMANCE	**MILITARY CONFIG**		**CIVIL CONFIG**
Payload (lb)	450,000		476,840
Range (nm)	4,000		3,500
Cruise Mach	0.78		0.78
Takeoff distance over 50 ft obstacle (ft)	9,500		-

TABLE C-5

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-111

ITEM	POUNDS	
Wing		370,499
Horizontal Tail		6,448
Vertical Tail		4,886
Fuselage		165,372
Landing Gear		43,899
Nose	5,707	
Main	38,192	
Nacelles/Pylons		11,171
Nacelles	4,594	
Pylons	6,577	
Noise Treatment	0	
Propulsion System		66,617
Engines	49,014	
Thrust Reversers	8,234	
Fuel System	5,899	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		38,449
Auxiliary Power System	1,430	
Surface Controls	9,690	
Instruments	1,706	
Hydraulics and Pneumatics	4,516	
Electrical	4,359	
Avionics	2,400	
Furnishings	8,028	
Air-conditioning and Anti-ice	6,090	
Auxiliary Gear-Equipment	230	
Weight Empty		475,564
Operating Equipment		14,991
Operating Weight		490,555
Payload		450,000
Zero Fuel Weight		940,555
Fuel		303,696
Gross Weight		1,244,251
AMPR Weight		401,497

TABLE C-6
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-111

LGA-144-111	OPERATING WEIGHT	490,555
Delete:		
Ramp Extensions	15,110	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	6,750	
Tiedown Rings	1,480	
Loadmasters	440	
Total	26,840	
LGA-144-111 C	OPERATING WEIGHT	463,715
Payload		476,840
ZERO FUEL WEIGHT		940,555
Fuel		303,696
GROSS WEIGHT		1,244,251

TABLE C-7
DESIGN AND PERFORMANCE DATA LGA-144-112

FUSELAGE GEOMETRY	
Length (ft)	279
Wetted Area (ft^2)	23,578
Pressure Volume (ft^3)	161,587
Cargo Compt L x W x H (ft)	204.8 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	8,477	993	951
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.50	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	298	67	34
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	64,984
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	405,000	431,030
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE C-8

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-112

ITEM	POUNDS	
Wing		221,485
Horizontal Tail		5,851
Vertical Tail		4,516
Fuselage		148,269
Landing Gear		39,478
Nose	5,132	
Main	34,346	
Nacelles/Pylons		10,105
Nacelles	4,223	
Pylons	5,882	
Noise Treatment	0	
Propulsion System		59,913
Engines	43,529	
Thrust Reversers	7,313	
Fuel System	5,601	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		36,493
Auxiliary Power System	1,318	
Surface Controls	8,861	
Instruments	1,655	
Hydraulics and Pneumatics	4,129	
Electrical	4,187	
Avionics	2,400	
Furnishings	7,810	
Air-conditioning and Anti-ice	5,925	
Auxiliary Gear-Equipment	207	
Weight Empty		426,110
Operating Equipment		13,308
Operating Weight		439,418
Payload		405,000
Zero Fuel Weight		844,418
Fuel		275,970
Gross Weight		1,120,388
AMPR Weight		359,795

TABLE C-9

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-112

LGA-144-112	OPERATING WEIGHT	439,418
Delete:		
Ramp Extensions	15,110	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	6,070	
Tiedown Rings	1,350	
Loadmasters	440	
Total	26,030	
LGA-144-112	OPERATING WEIGHT	413,388
Payload		431,030
ZERO FUEL WEIGHT		844,418
Fuel		275,970
GROSS WEIGHT		1,120,388

TABLE C-10

DESIGN AND PERFORMANCE DATA LGA-144-113

FUSELAGE GEOMETRY			
Length (ft)	259		
Wetted Area (ft^2)	21,730		
Pressure Volume (ft^3)	148,167		
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 13.5		
Forward Aperture Width (ft)	19.5		
Aft Aperture Width (ft)	13.0		

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,554	895	868
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.49	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	281	63	33
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	57,976
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	385,220
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE C-11

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-113

ITEM	POUNDS	
Wing		104,935
Horizontal Tail		5,255
Vertical Tail		4,137
Fuselage		131,778
Landing Gear		35,134
Nose	4,567	
Main	30,567	
Nacelles/Pylons		9,060
Nacelles	3,853	
Pylons	5,208	
Noise Treatment	0	
Propulsion System		53,429
Engines	38,241	
Thrust Reversers	6,425	
Fuel System	5,293	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,522
Auxiliary Power System	1,209	
Surface Controls	8,040	
Instruments	1,601	
Hydraulics and Pneumatics	3,747	
Electrical	4,009	
Avionics	2,400	
Furnishings	7,581	
Air-conditioning and Anti-ice	5,751	
Auxiliary Gear-Equipment	185	
Weight Empty		378,251
Operating Equipment		11,699
Operating Weight		389,950
Payload		360,000
Zero Fuel Weight		749,950
Fuel		248,703
Gross Weight		998,652
AMPR Weight		319,457

TABLE C-12
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-113

LGA-144-113	OPERATING WEIGHT	389,950
Delete:		
Ramp Extensions	15,110	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,400	
Tiedown Rings	1,210	
Loadmasters	440	
Total	25,220	
LGA-144-113C	OPERATING WEIGHT	364,730
Payload		385,220
ZERO FUEL WEIGHT		749,950
Fuel		248,703
GROSS WEIGHT		998,653

TABLE C-13
DESIGN AND PERFORMANCE DATA LGA-144-114

FUSELAGE GEOMETRY

Length (ft)	239
Wetted Area (ft^2)	19,882
Pressure Volume (ft^3)	134,747
Cargo Compt L x W x H (ft)	164.3 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	6,645	797	782
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.47	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	264	60	31
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	51,071
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	315,000	339,410
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE C-14

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-114

ITEM	POUNDS	
Wing		89,124
Horizontal Tail		4,662
Vertical Tail		3,750
Fuselage		115,921
Landing Gear		30,865
Nose	4,012	
Main	26,853	
Nacelles/Pylons		8,029
Nacelles	3,480	
Pylons	4,548	
Noise Treatment	0	
Propulsion System		47,120
Engines	33,115	
Thrust Reversers	5,563	
Fuel System	4,972	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		32,530
Auxiliary Power System	1,101	
Surface Controls	7,225	
Instruments	1,543	
Hydraulics and Pneumatics	3,367	
Electrical	3,823	
Avionics	2,400	
Furnishings	7,340	
Air-conditioning and Anti-ice	5,567	
Auxiliary Gear-Equipment	163	
Weight Empty		332,001
Operating Equipment		10,161
Operating Weight		342,162
Payload		315,000
Zero Fuel Weight		657,162
Fuel		221,804
Gross Weight		878,966
AMPR Weight		280,532

TABLE C-15

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-114

LGA-144- 114		OPERATING WEIGHT	342,162
Delete:			
Ramp Extensions	15,110		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	430		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	4,720		
Tiedown Rings	1,080		
Loadmasters	440		
Total	24,410		
LGA-144- 114 C		OPERATING WEIGHT	317,752
Payload			339,410
ZERO FUEL WEIGHT			657,162
Fuel			221,804
GROSS WEIGHT			878,966

CRUISE MACH NO.	0.78
DESIGN PAYLOAD	495,000 LB
DESIGN RANGE	4,000 NM
OPERATING WEIGHT	543,000 LB
MAX GROSS WEIGHT	1,370,000 LB
ASPECT RATIO	10.5
WING LOADING	129.4 PSF
THRUST PER ENGINE	80,000 LB

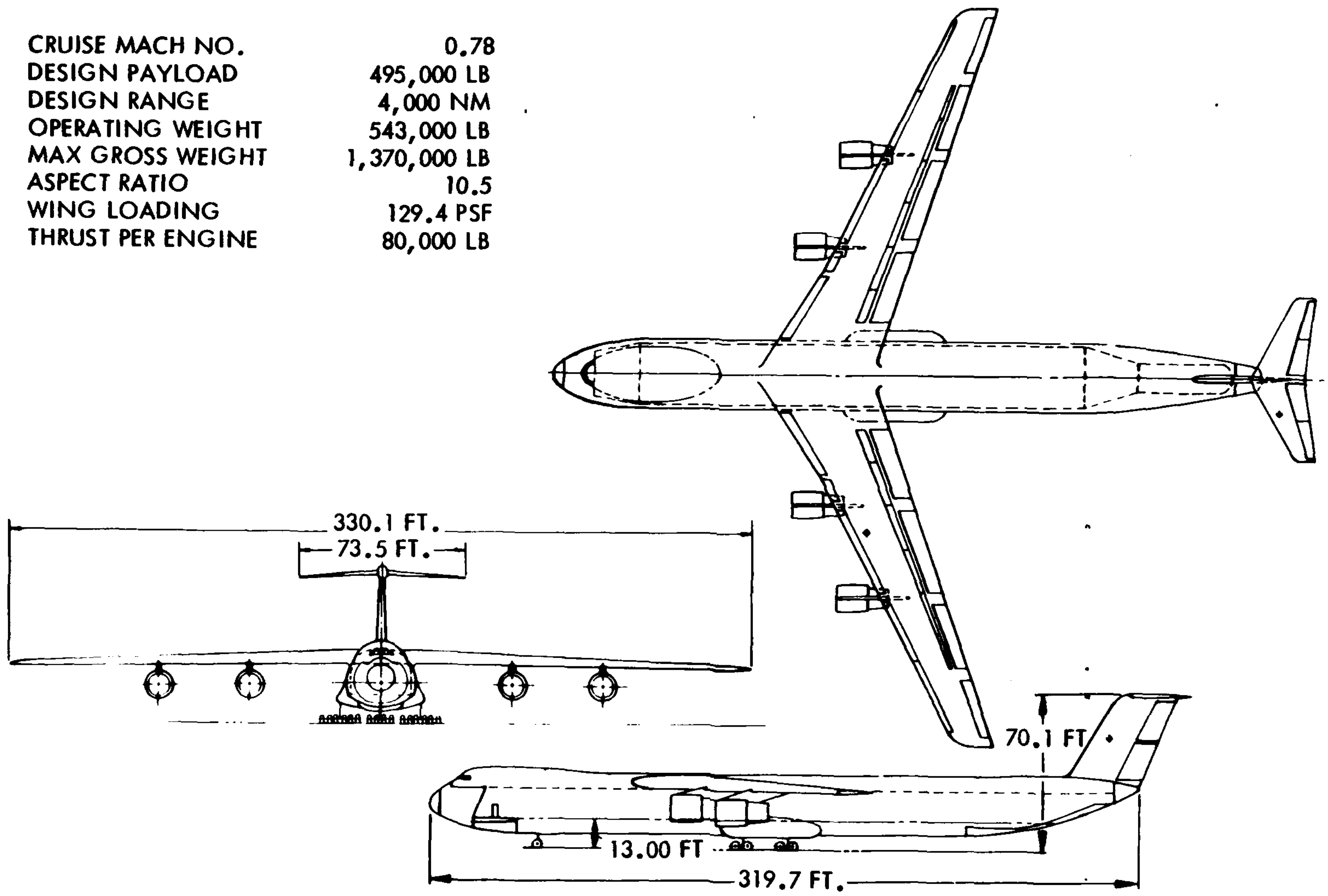


Figure C-1. Baseline Aircraft General Arrangement

CRUISE MACH NO	0.78
DESIGN PAYLOAD	315,000 LB
DESIGN RANGE	4,000 NM
OPERATING WEIGHT	342,000 LB
MAX GROSS WEIGHT	879,000 LB
ASPECT RATIO	10.5
WING LOADING	129.4 PSF
THRUST PER ENGINE	51,000 LB

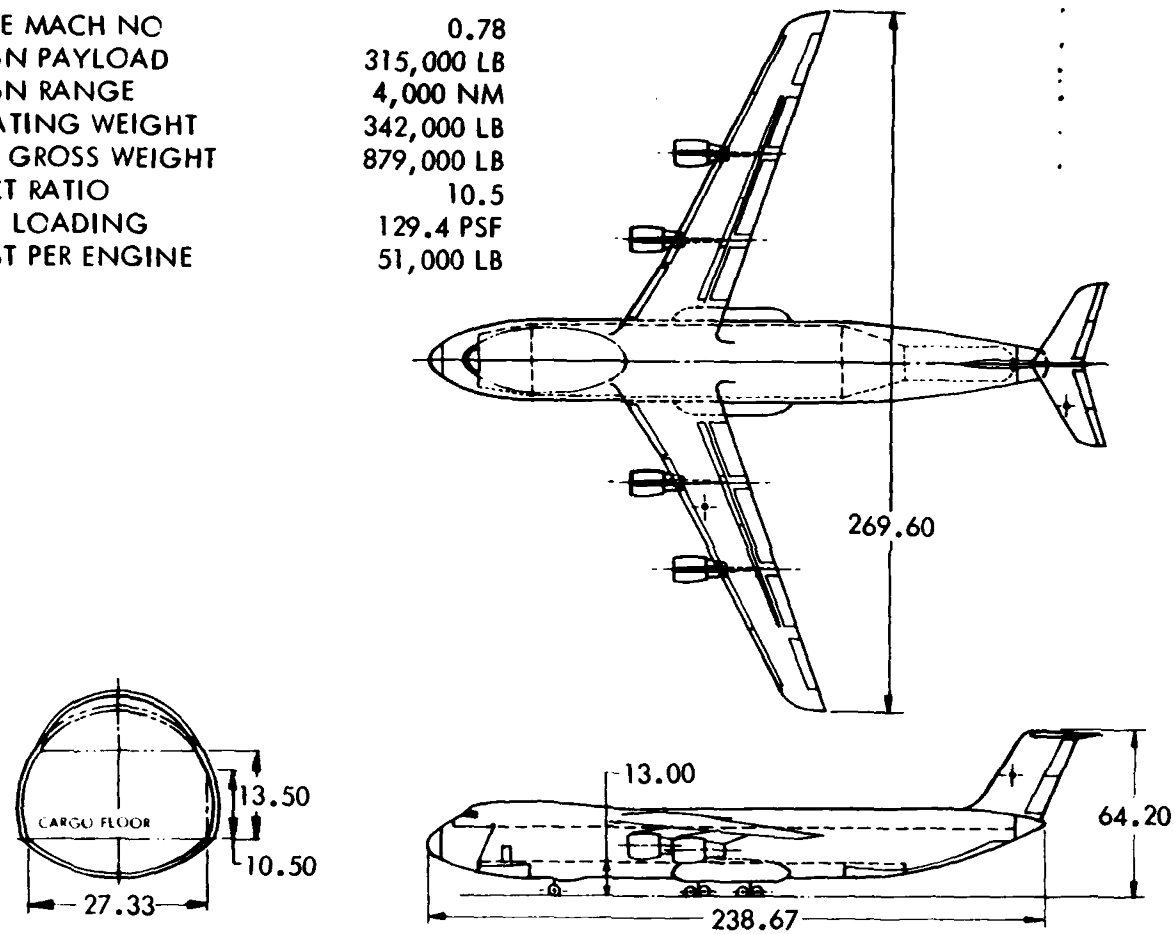


Figure C-2. LGA-144-114 General Arrangement

APPENDIX D. DESCRIPTION OF GROUP II CONFIGURATIONS

This appendix defines the Group II baseline (LGA-144-200) and all other Group II configurations. The -200 baseline was derived from the -113 which was the preferred configuration of the Group I series. The foldout page at the back of this volume gives the configuration identification and a brief description of the six configurations which will be defined in this appendix.

LGA-144-200 BASELINE CONFIGURATION

As noted above, the -200 baseline configuration was derived from the -113; however, the two configurations are not identical. A three view of the -200 is shown in Figure D-1 along with some of its more pertinent design characteristics. The -200 incorporates the same landing gear system rolling stock as the -100; hence, it provides LCG III flotation. The configuration was re-optimized using the GASP program to produce slightly different physical characteristics from the -113.

Tables D-1, D-2, and D-3 provide:

- o Design and performance data
- o Military group weight summary
- o Summary of weight changes to get commercial configuration for the -200 configuration.

The payload-range curve for the -200 is depicted in Figure D-2, and the cargo floor planform with its twenty-four containers (20-foot long) is shown in Figure D-3.

Figure D-4 shows the forward fuselage arrangements while Figure D-5 shows the nose visor, forward opening, and ramp arrangement. Note the opening is 19.5 feet wide with a 13.5-foot cargo compartment height.

The aft fuselage is depicted in Figure D-6 and D-7. Note the aft opening is 13.0 feet wide and has a 9.5-foot clearance for aerial delivery.

CRUISE MACH NO.	0.78
DESIGN PAYLOAD	360,000 LB
DESIGN RANGE	4,000 NM
OPERATING WEIGHT	400,000 LB
MAX GROSS WEIGHT	1,011,000 LB
ASPECT RATIO	10.5
WING LOADING	129.4 PSF
THRUST PER ENGINE	59,000 LB

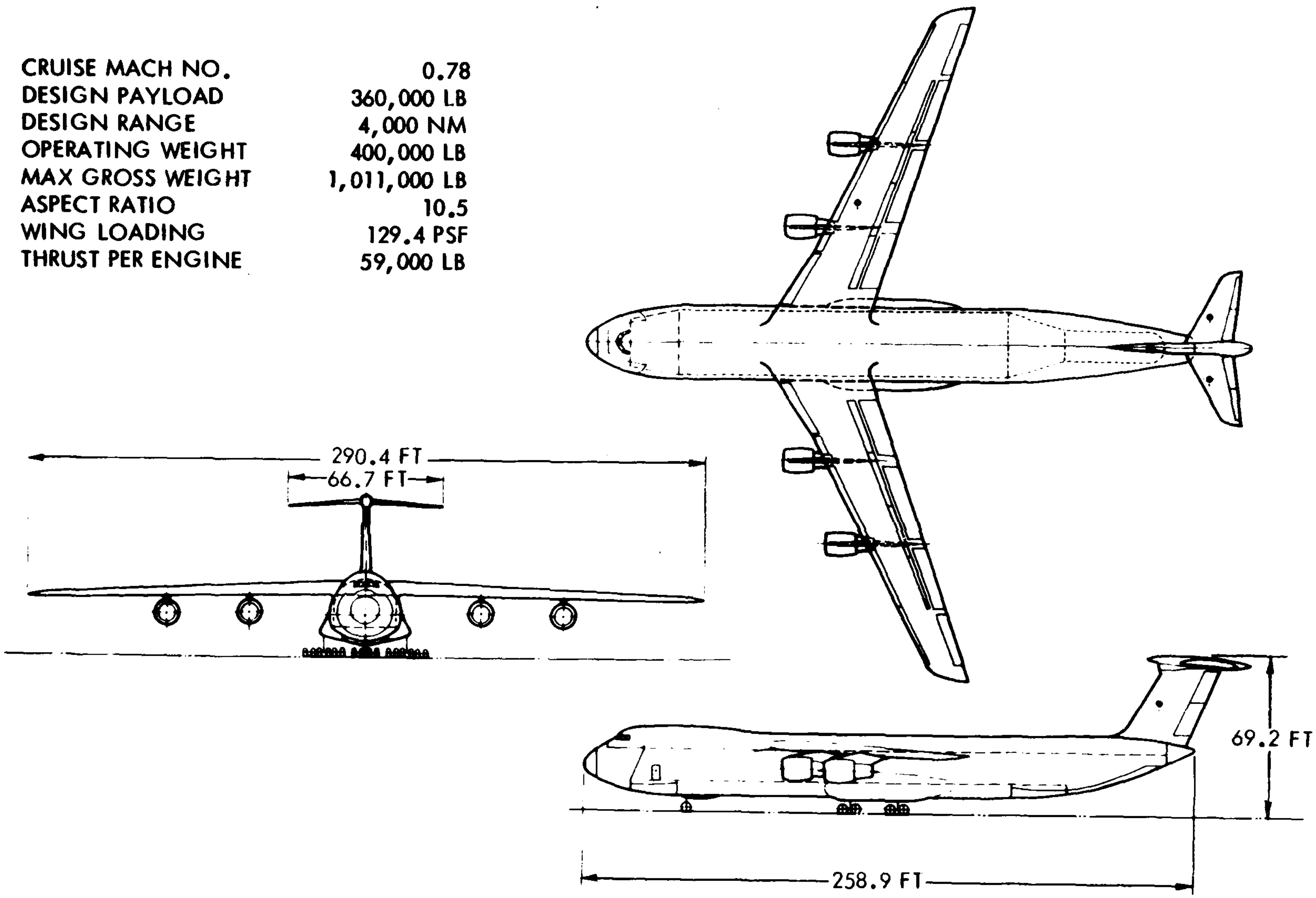


Figure D-1. LGA-144-200 General Arrangement

TABLE D-1
DESIGN AND PERFORMANCE DATA LGA-144-200

FUSELAGE GEOMETRY

Length (ft)	259
Wetted Area (ft^2)	21,730
Pressure Volume (ft^3)	148,167
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,647	912	883
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.48	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	283	64	33
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	58,702
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	373,162
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE D-2
GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-200

ITEM	POUNDS	
Wing		106,495
Horizontal Tail		5,345
Vertical Tail		4,200
Fuselage		131,893
Landing Gear		41,862
Nose	5,442	
Main	36,420	
Nacelles/Pylons		9,169
Nacelles	3,891	
Pylons	5,277	
Noise Treatment	0	
Propulsion System		54,096
Engines	38,785	
Thrust Reversers	6,516	
Fuel System	5,325	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,676
Auxiliary Power System	1,220	
Surface Controls	8,127	
Instruments	1,603	
Hydraulics and Pneumatics	3,787	
Electrical	4,017	
Avionics	2,400	
Furnishings	7,581	
Air-conditioning and Anti-ice	5,754	
Auxiliary Gear-Equipment	187	
Weight Empty		387,735
Operating Equipment		11,792
Operating Weight		399,528
Payload		360,000
Zero Fuel Weight		759,528
Fuel		251,371
Gross Weight		1,010,899
AMPR Weight		325,094

TABLE D-3
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-200

LGA-144-200	OPERATING WEIGHT	399,528
Delete:		
Ramp Extensions	4,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,400	
Tiedown Rings	1,210	
Loadmasters	440	
Total	14,910	
LGA-144-200 C	OPERATING WEIGHT	384,618
Payload		374,910
ZERO FUEL WEIGHT		759,528
Fuel		251,371
GROSS WEIGHT		1,010,899

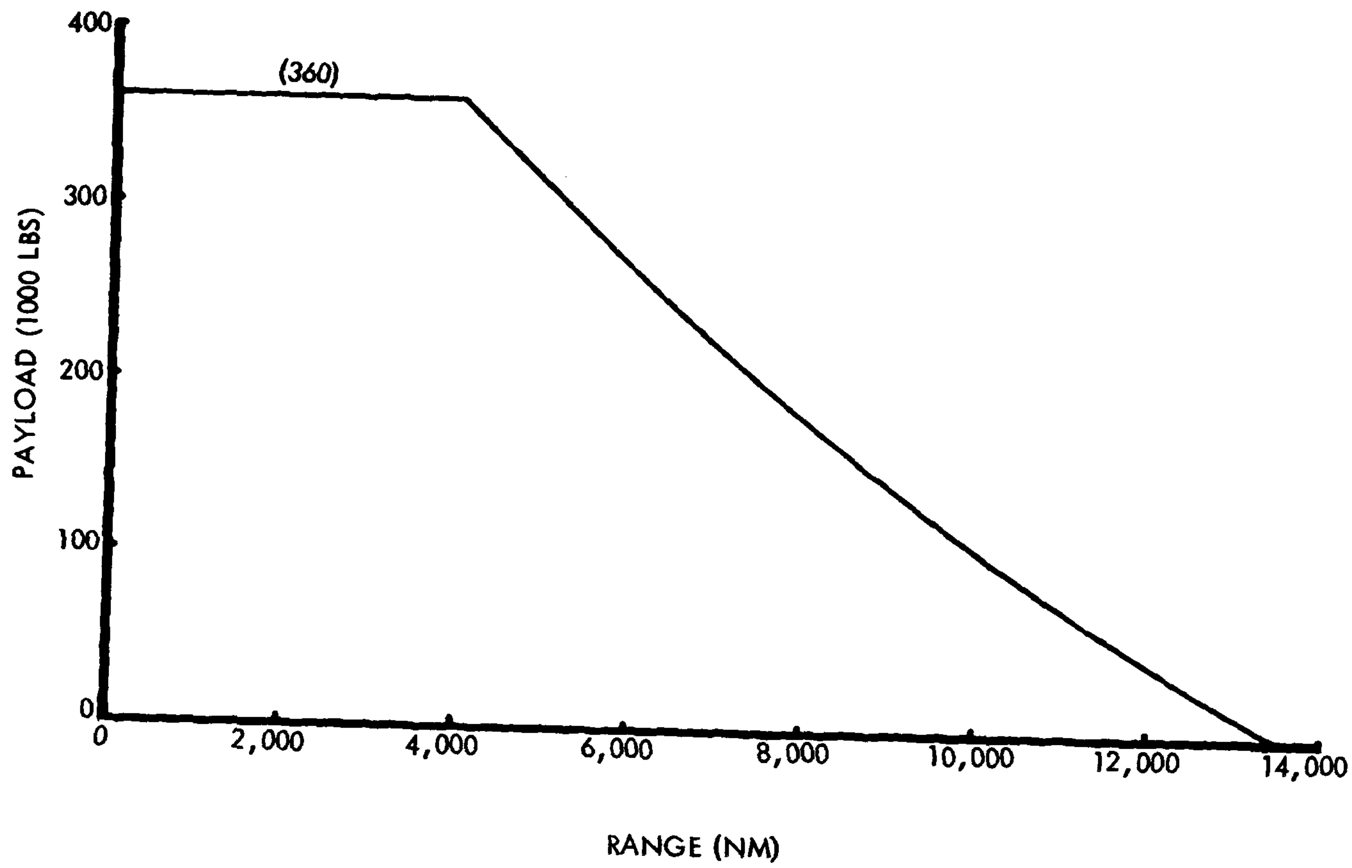
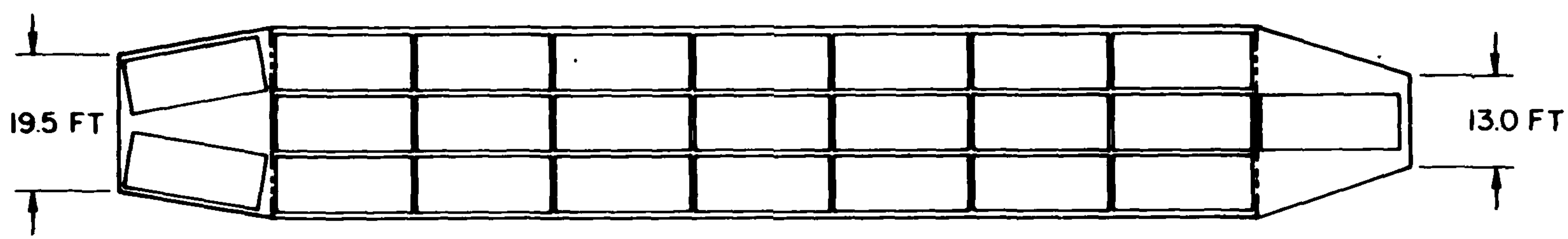


Figure D-2. LGA-144-200 Payload-Range



24 X 15,000 LB = 360,000 LB PAYLOAD

Figure D-3. LGA-144-200 Cargo Compartment Planform

MODEL NO. LGA-144-200

WETTED AREA: 21,730 FT^2

PRESSURIZED VOLUME: 148,167 FT^3

LENGTH OF FUSELAGE: 258.92 FT

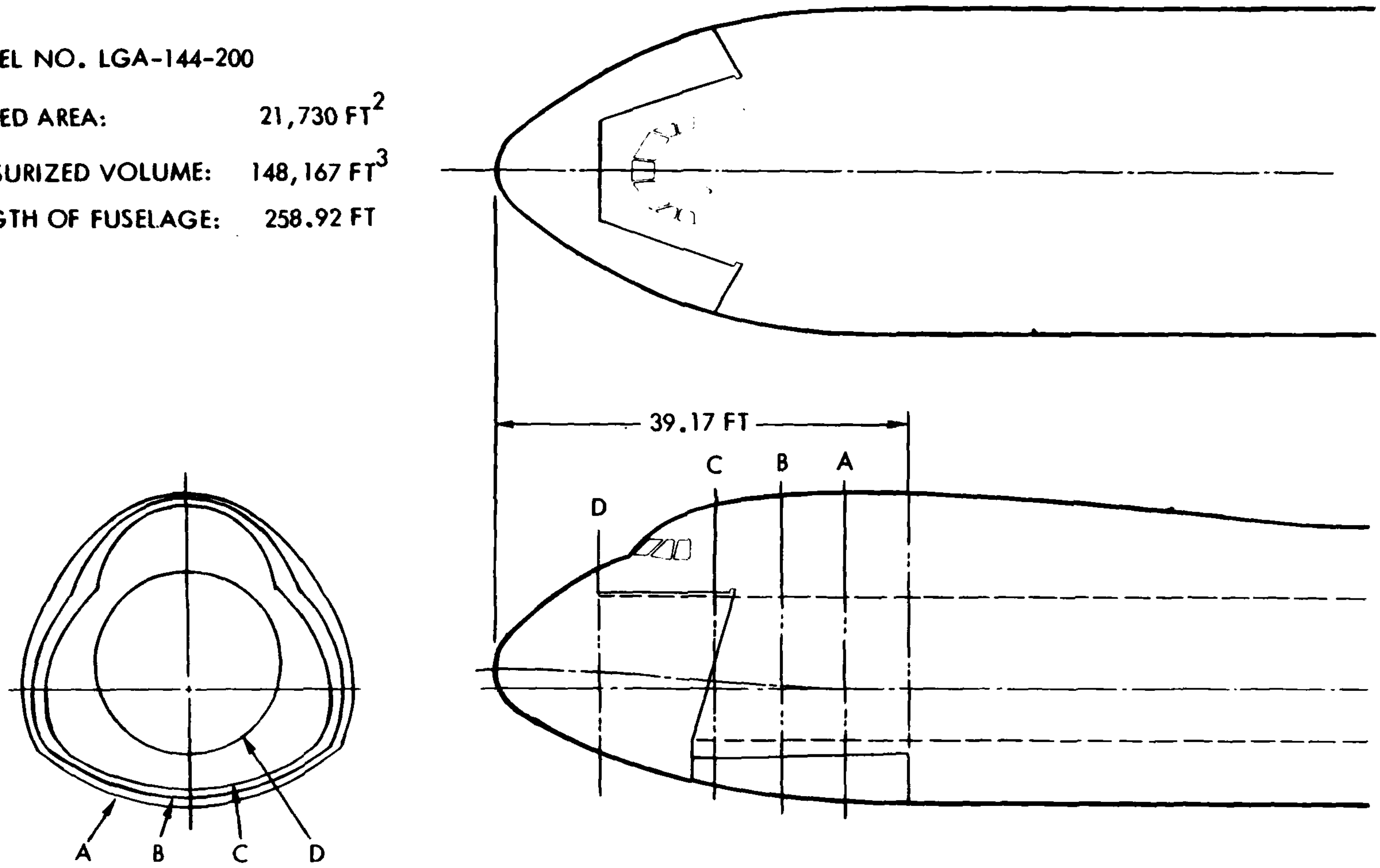


Figure D-4 . Baseline Forward Fuselage Arrangement (LGA-144-200)

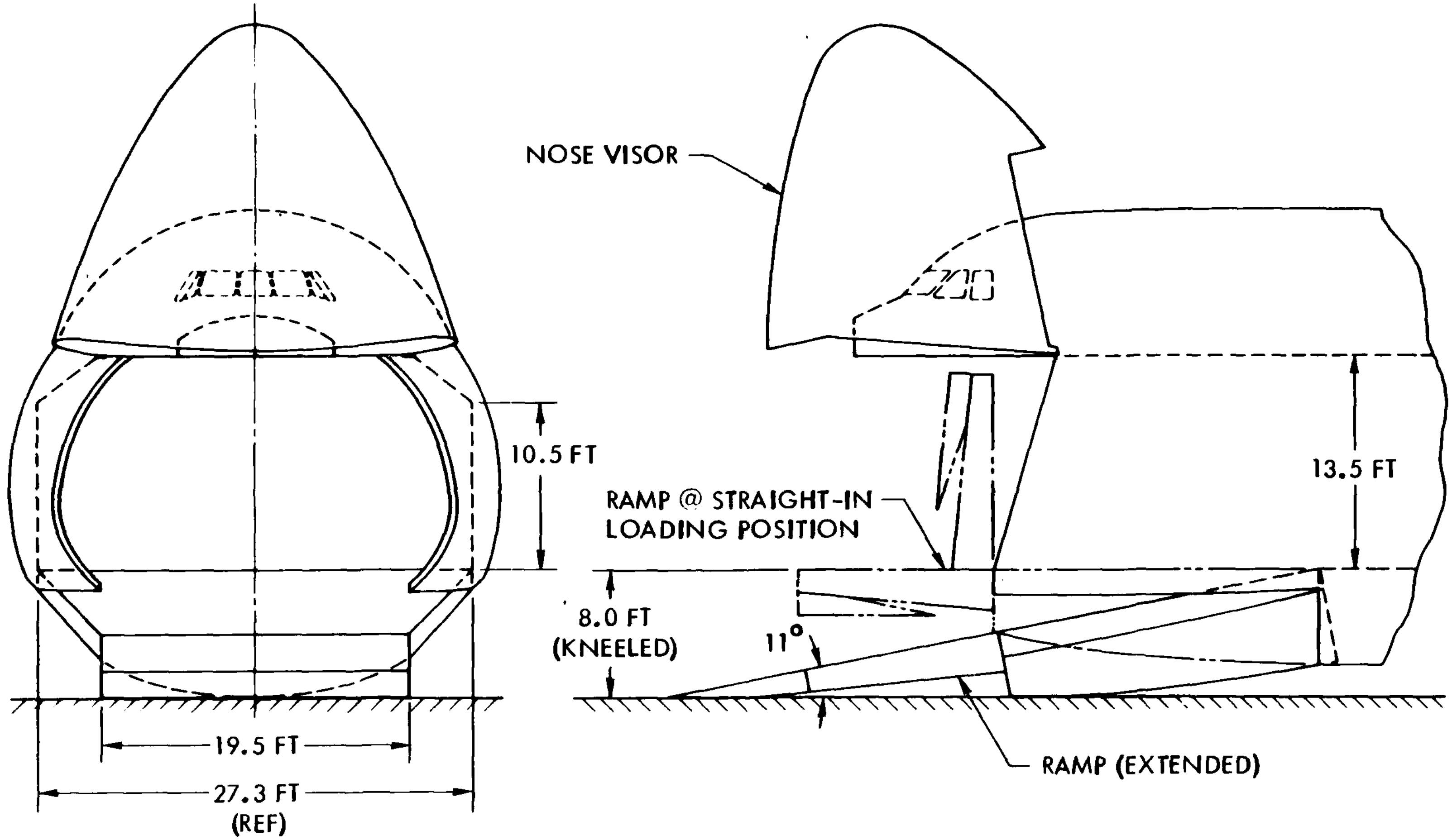


Figure D-5. Baseline Aircraft Forward Fuselage

MODEL NO. LGA-144-200	
WETTED AREA:	21,730 FT^2
PRESSURIZED VOLUME:	148,167 FT^3
LENGTH OF FUSELAGE:	258.92 FT

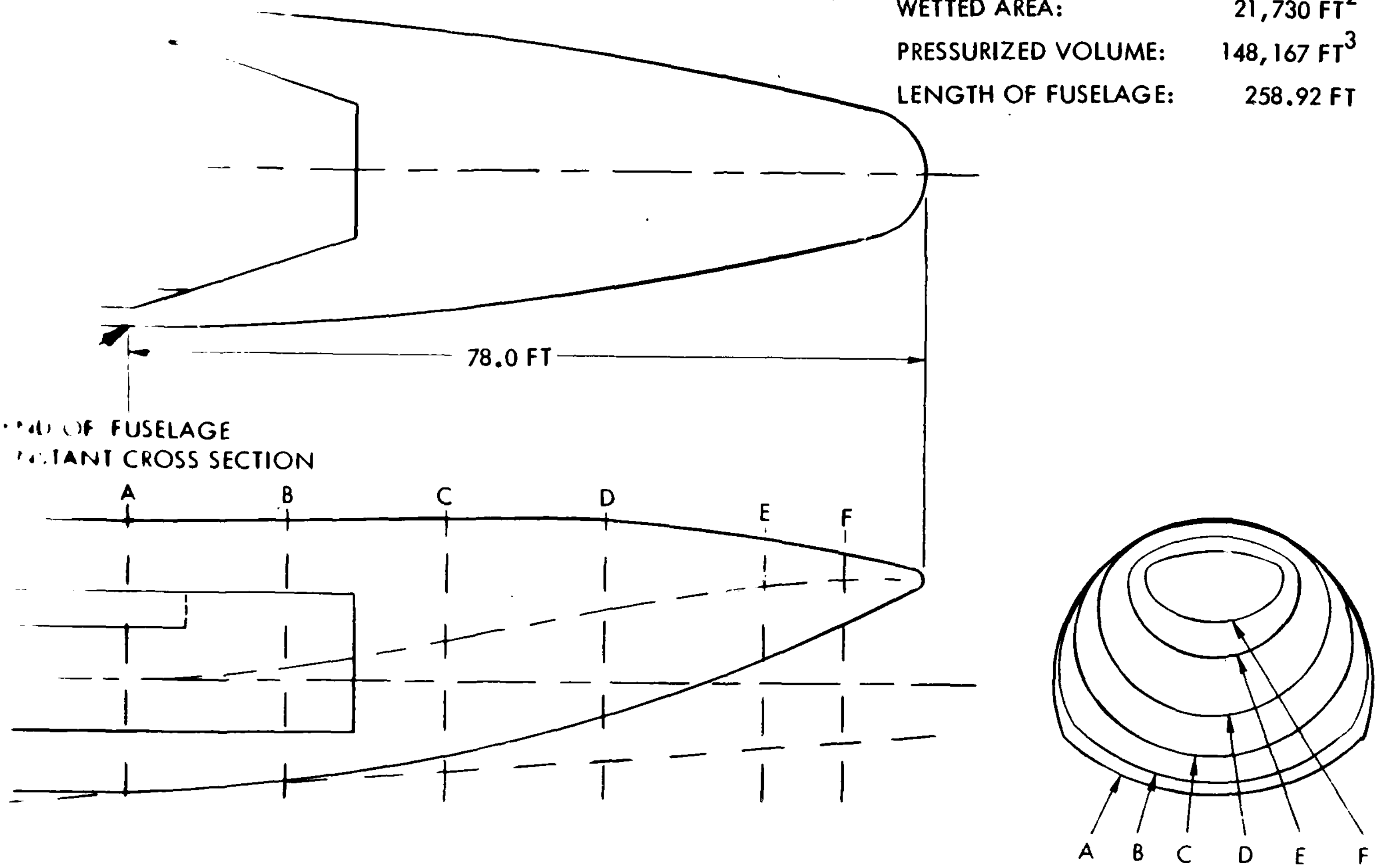


Figure D-6. Baseline Aft Fuselage Arrangement (LGA-144-200)

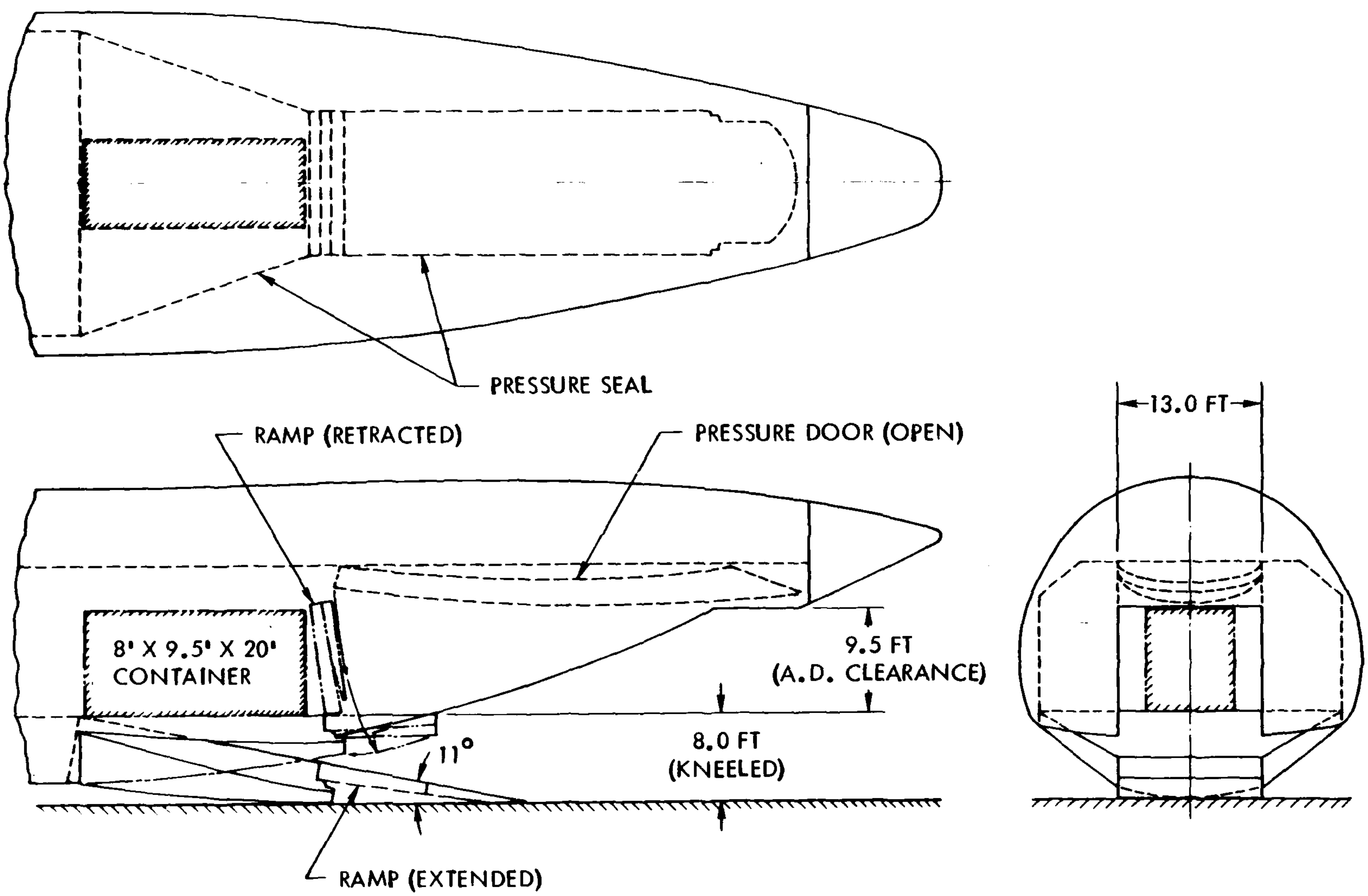


Figure D-7. Baseline Aircraft Aft Fuselage

The aft pressure door is a single-piece retractable pressure door as described in Appendix A.

These forward and aft fuselage arrangements are identical to the Group I configurations. The primary function of the Group II configurations is an examination of differing forward and aft fuselage apertures.

LGA-144-211

The -211 point design was derived from the -200 baseline configuration to assess the cost effectiveness of the rear aperture. The objective of the redesign was to take maximum advantage of the deletion of the requirement to have an aft aperture. Examination of Figure D-7 shows considerable wasted floor area around the single container position in the -200 aft fuselage. The design of the -211 utilizes this space by locating two containers angling in from the outboard sticks. Fuselage upsweep is reduced as much as possible without changing the takeoff rotation angle. The broad shape of the -200 aftbody is replaced with a taper comparable to the side view, giving the new aftbody lines shown on Figure D-8.

The -211 was optimized with this new aftbody using the GASP. A tabular description of this aircraft is found in Tables D-4, D-5, and D-6.

LGA-144-221

The -221 point design features full-width openings at both the front and rear of the aircraft. The penalties present on the -200 for these apertures are magnified for the -221, due to the larger openings. At the rear, separate pressure door and fuselage petal doors similar to the C-5A arrangement are incorporated to provide for the full-width opening. At the front, the visor door is enlarged 20 percent and the actuation and latching mechanisms improved to take the load.

However, the cargo floor planform is enlarged such that three more containers can be loaded, increasing the payload to 405,000 pounds in accordance with Volume II. See Figures D-9 and D-10 for the forebody and aftbody geometry on the -221.

MODEL NO. LGA-144-211	
WETTED AREA:	20,308 FT^2
PRESSURIZED VOLUME:	139,647 FT^3
LENGTH OF FUSELAGE:	241.50 FT

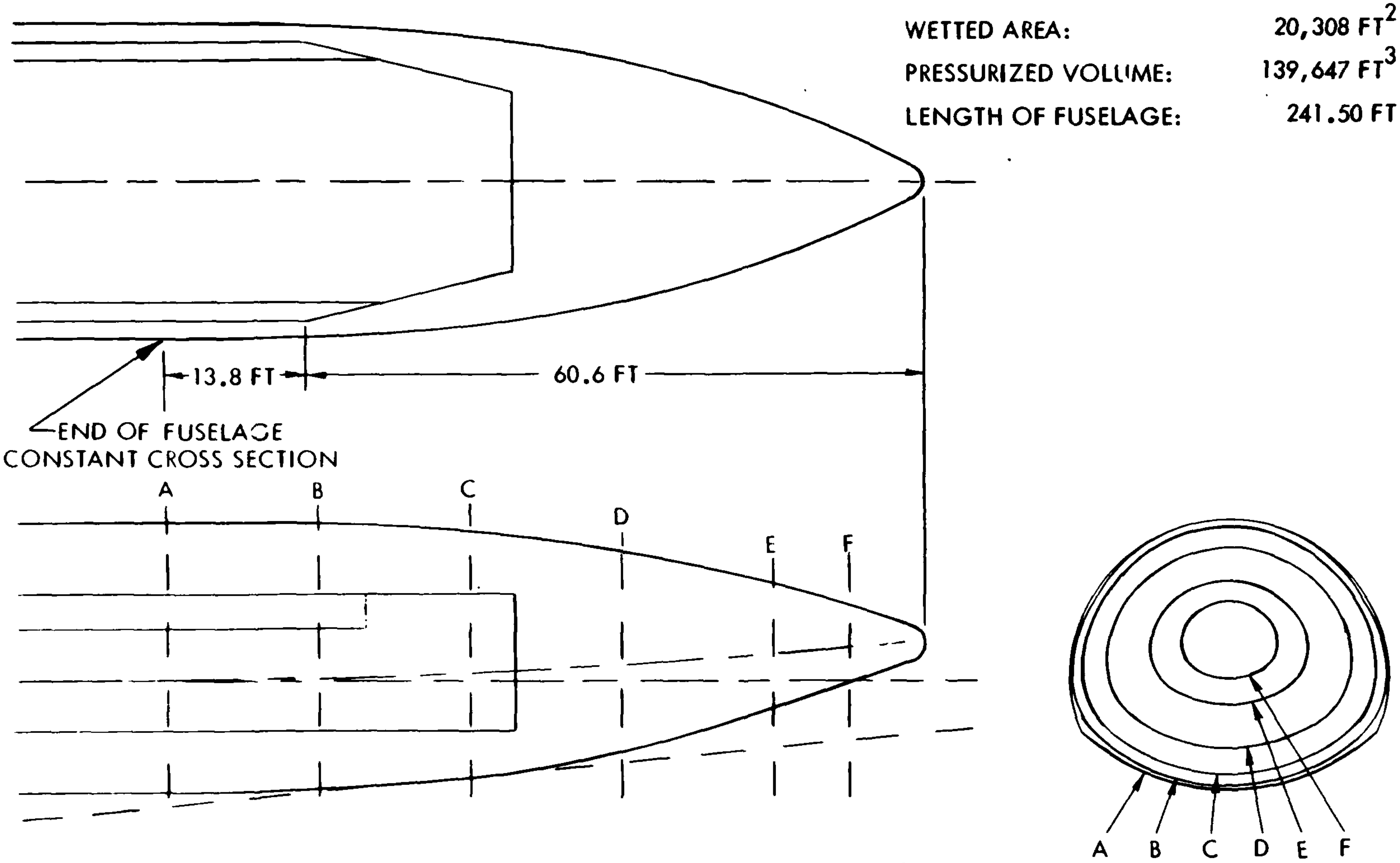


Figure D-8. Aft Fuselage Arrangement with No Aperture

TABLE D-4
DESIGN AND PERFORMANCE DATA LGA-144-211

FUSELAGE GEOMETRY			
Length (ft)	242		
Wetted Area (ft^2)	20,308		
Pressure Volume (ft^3)	139,674		
Cargo Compt L x W x H (ft)	182.6 x 27.3 x 13.5		
Forward Aperture Width (ft)	19.5		
Aft Aperture Width (ft)	None		
SURFACE GEOMETRY	**WING**	**HORIZ**	**VERT**
Area (ft^2) (Basic)	7,535	898	1,021
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.51	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	281	64	36
Wing Loading (lb/ft^2)	129 35	-	-
ENGINE			
Thrust (Sea Level Static - lb)	57,754		
TSFC (Cruise lb/lb/hr)	0.594		

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	375,000	387,990
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE D-5

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-211

ITEM	POUNDS	
Wing		105,392
Horizontal Tail		5,263
Vertical Tail		4,635
Fuselage		114,242
Landing Gear		41,648
Nose	5,414	
Main	36,234	
Nacelles/Pylons		9,027
Nacelles	3,841	
Pylons	5,186	
Noise Treatment	0	
Propulsion System		53,177
Engines	38,075	
Thrust Reversers	6,397	
Fuel System	5,236	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		33,921
Auxiliary Power System	1,206	
Surface Controls	8,022	
Instruments	1,574	
Hydraulics and Pneumatics	3,738	
Electrical	3,928	
Avionics	2,400	
Furnishings	7,213	
Air-conditioning and Anti-ice	5,654	
Auxiliary Gear-Equipment	184	
Weight Empty		367,305
Operating Equipment		11,902
Operating Weight		379,207
Payload		375,000
Zero Fuel Weight		754,207
Fuel		241,105
Gross Weight		995,312
AMPR Weight		305,511

TABLE D-6
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-211

LGA-144-211	OPERATING WEIGHT	379,207
Delete:		
Ramp Extensions	2,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	280	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,620	
Tiedown Rings	1,220	
Loadmasters	440	
Total	12,990	
LGA-144-211 C	OPERATING WEIGHT	366,217
Payload		387,990
ZERO FUEL WEIGHT		754,207
Fuel		241,105
GROSS WEIGHT		995,312

MODEL NO. LGA-144-221	
WETTED AREA:	23,468 FT^2
PRESSURIZED VOLUME:	159,970 FT^3
LENGTH OF FUSELAGE:	276.11 FT

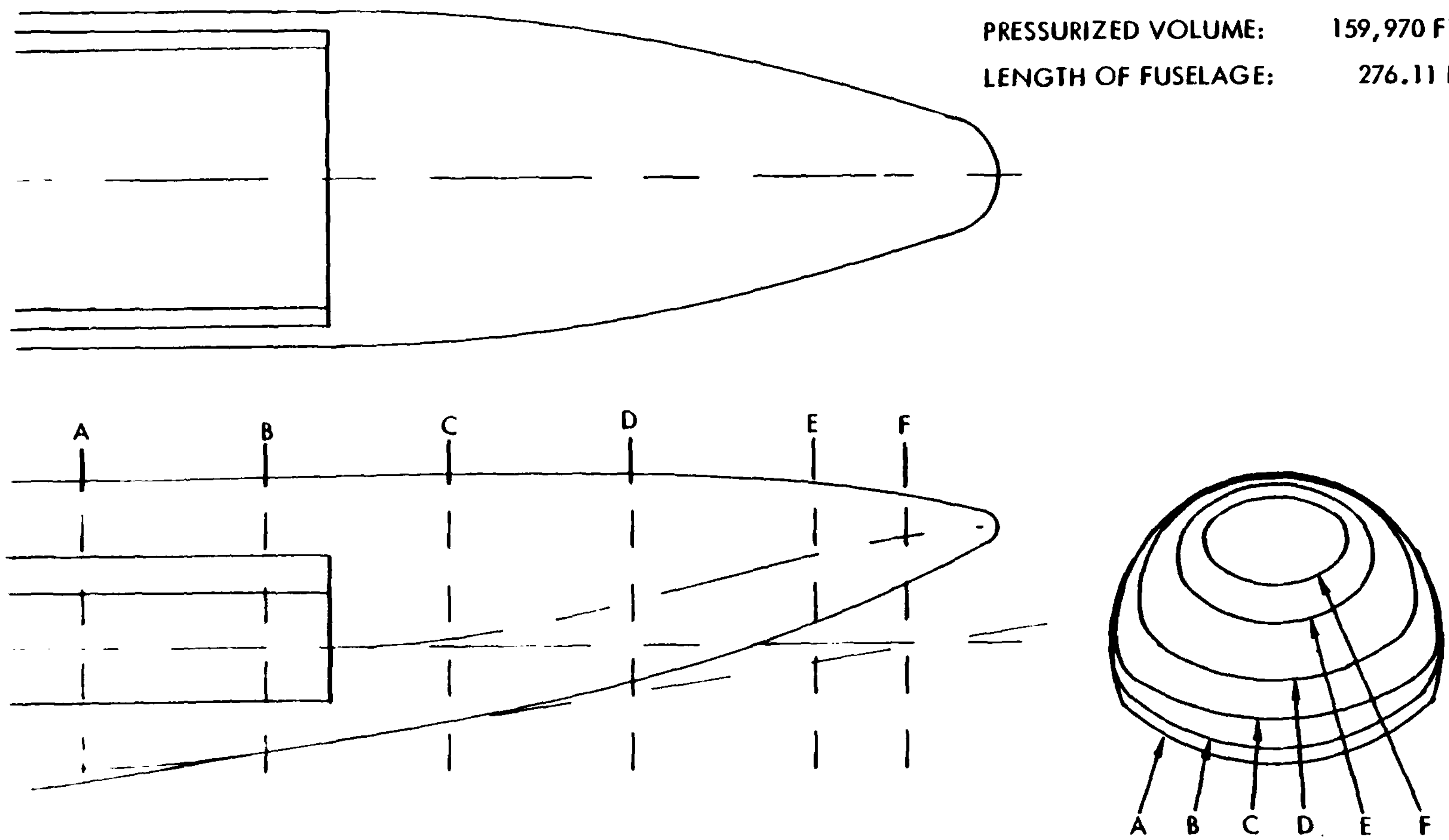


Figure D-9. Aft Fuselage with Full-Width Aperture

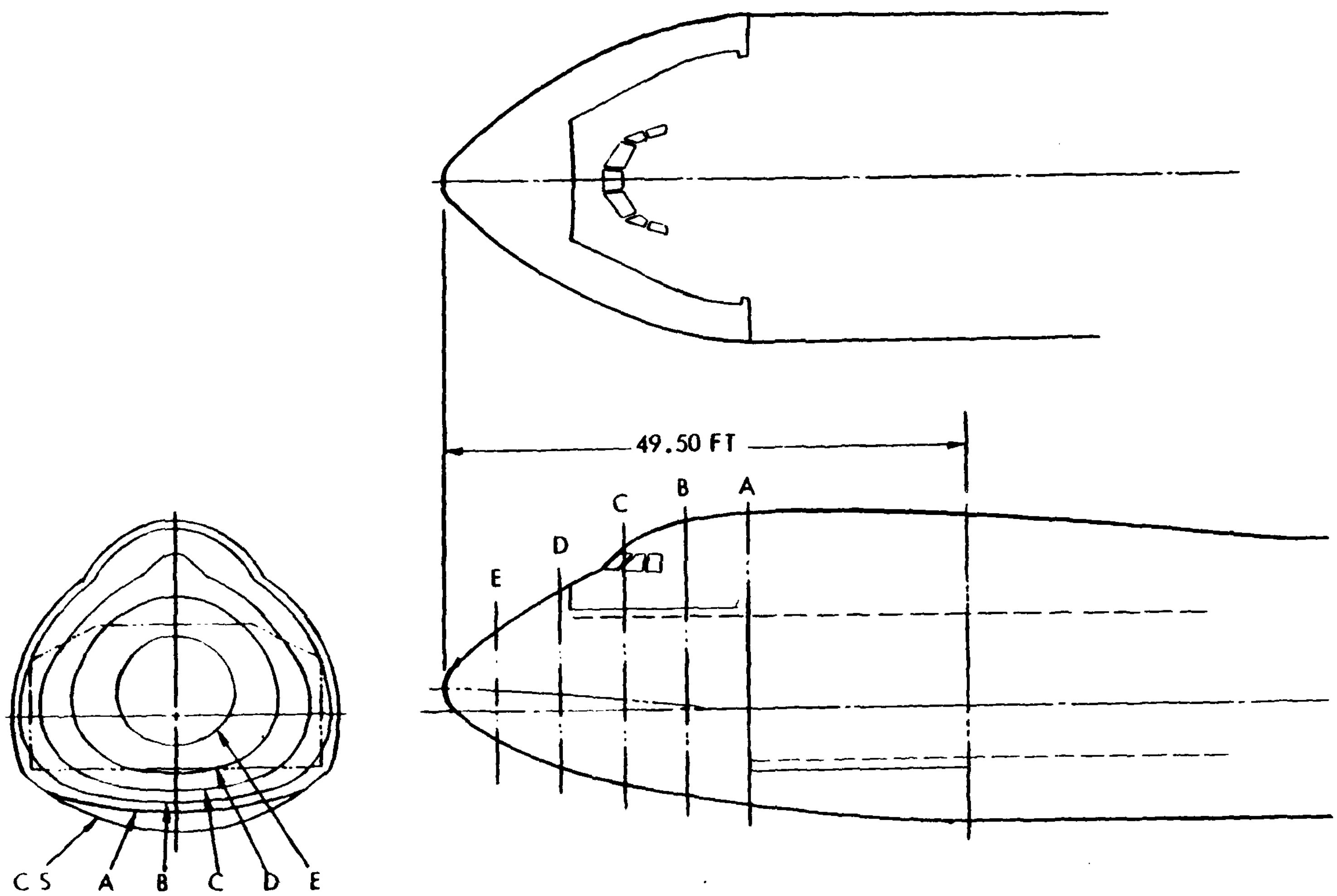


Figure D-10. Forward Fuselage with Full-Width Aperture

After optimization of this configuration using the GASP program, the performance and physical characteristics of the -221 are defined as shown in Tables D-7, D-8, and D-9.

LGA-144-222

The -222 point design incorporates a full-width forward aperture with the baseline rear aperture. The -222 has the same forward opening and floor plan as the -221 shown in Figure D-9; however, the rear opening, ramp arrangement, pressure door, and aft fuselage floor plan are the same as the baseline, as shown in Figures D-6 and D-7. Payload is increased by 15,000 lb to 375,000 lb due to the extra container position on the forward ramp. The reoptimized point design configuration for the -222 produced the data shown in Tables D-10, D-11, and D-12.

LGA-144-223

This configuration has a full-width forward aperture like the -221 with the aft fuselage configuration of the -211. The revised cargo compartment planform shape allows two additional container positions increasing the payload to 390,000 lb.

The reoptimized aircraft has the physical and performance characteristics shown in Tables D-13, D-14, and D-15.

LGA-144-231

The last Group II option looks at the cost-effectiveness implications of a kneeling versus non-kneeling landing gear. Recall that the -200 baseline configuration normally has a cargo floor height of 13 feet, but kneels to an 8-foot height for loading/unloading operations. The -231 was configured without the kneeling capability; i.e., the cargo floor remains at 13 feet above the ground.

The basic cargo section of the -231 is identical to the -200 baseline. The significantly different feature of the -231 is its ramp extensions. Provided

TABLE D-7

DESIGN AND PERFORMANCE DATA LGA-144-221

FUSELAGE GEOMETRY	
Length (ft)	276
Wetted Area (ft^2)	23,468
Pressure Volume (ft^3)	159,970
Cargo Compt L x W x H (ft)	184.8 x 27.3 x 13.5
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	27.3

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	8,628	161	139
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.48	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	301	69	37
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	66,255
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	405,000	419,107
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE D-8

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-221

ITEM	POUNDS	
Wing		123,699
Horizontal Tail		6,149
Vertical Tail		4,942
Fuselage		151,240
Landing Gear		44,188
Nose	5,744	
Main	38,444	
Nacelles/Pylons		10,294
Nacelles	4,289	
Pylons	6,005	
Noise Treatment	0	
Propulsion System		61,115
Engines	44,496	
Thrust Reversers	7,475	
Fuel System	5,674	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		36,677
Auxiliary Power System	1,337	
Surface Controls	9,025	
Instruments	1,654	
Hydraulics and Pneumatics	4,206	
Electrical	4,185	
Avionics	2,400	
Furnishings	7,746	
Air-conditioning and Anti-ice	5,914	
Auxiliary Gear-Equipment	211	
Weight Empty		438,305
Operating Equipment		13,471
Operating Weight		451,775
Payload		405,000
Zero Fuel Weight		856,775
Fuel		283,892
Gross Weight		1,140,667
AMPR Weight		368,707

TABLE D-9
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-221

LGA-144-221	OPERATING WEIGHT	451,775
Delete:		
Ramp Extensions	5,410	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	6,070	
Tiedown Rings	1,280	
Loadmasters	440	
Total	16,260	
LGA-144-221 C	OPERATING WEIGHT	435,515
Payload		421,260
ZERO FUEL WEIGHT		856,775
Fuel		283,892
GROSS WEIGHT		1,140,667

TABLE D-10

DESIGN AND PERFORMANCE DATA LGA-144-222

FUSELAGE GEOMETRY			
Length (ft)	269		
Wetted Area (ft^2)	22,697		
Pressure Volume (ft^3)	154,455		
Cargo Compt L x W x H (ft)	184.8 x 27.3 x 13.5		
Forward Aperture Width (ft)	27.3		
Aft Aperture Width (ft)	13.0		
SURFACE GEOMETRY	**WING**	**HORIZ**	**VERT**
Area (ft^2) (Basic)	8,025	971	1,043
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.48	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	290	66	36
Wing Loading (lb/ft^2)	129.35	-	-
ENGINE			
Thrust (Sea Level Static - lb)	61,608		
TSFC (Cruise lb/lb/hr)	0.594		
PERFORMANCE	**MILITARY CONFIG**	**CIVIL CONFIG**	
Payload (lb)	375,000	389,133	
Range (nm)	4,000	3,500	
Cruise Mach	0.78	0.78	
Takeoff distance over 50 ft obstacle (ft)	9,500	-	

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DESIGN OPTIONS STUDY. VOLUME IV. DETAILED ANALYSES SUPPORTING A--ETC(U)
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UNCLASSIFIED LG80ER0009 NL

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TABLE D-11

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-222

ITEM	POUNDS	
Wing		113,092
Horizontal Tail		5,667
Vertical Tail		4,763
Fuselage		141,689
Landing Gear		42,761
Nose	5,559	
Main	37,202	
Nacelles/Pylons		9,602
Nacelles	4,045	
Pylons	5,557	
Noise Treatment	0	
Propulsion System		57,785
Engines	40,972	
Thrust Reversers	6,883	
Fuel System	5,460	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		35,526
Auxiliary Power System	1,265	
Surface Controls	8,476	
Instruments	1,628	
Hydraulics and Pneumatics	3,950	
Electrical	4,100	
Avionics	2,400	
Furnishings	7,674	
Air-conditioning and Anti-ice	5,838	
Auxiliary Gear-Equipment	196	
Weight Empty		409,887
Operating Equipment		12,397
Operating Weight		422,284
Payload		375,000
Zero Fuel Weight		797,284
Fuel		263,586
Gross Weight		1,060,870
AMPR Weight		344,573

TABLE D-12
SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-222

LGA-144-222		OPERATING WEIGHT	422,287
Delete:			
Ramp Extensions	5,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	430		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,620		
Tiedown Rings	1,230		
Loadmasters	440		
Total	16,150		
LGA-144-222 C		OPERATING WEIGHT	406,137
Payload			391,150
ZERO FUEL WEIGHT			797,287
Fuel			263,583
GROSS WEIGHT			1,060,870

TABLE D-13
DESIGN AND PERFORMANCE DATA LGA-144-223

FUSELAGE GEOMETRY

Length (ft)	252
Wetted Area (ft^2)	21,275
Pressure Volume (ft^3)	145,962
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 13.5
Forward Aperture Width (ft)	23.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,891	951	1,067
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.50	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	288	65	37
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	60,508
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	390,000	404,250
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE D-14

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-223

ITEM	POUNDS	
Wing		111,536
Horizontal Tail		5,554
Vertical Tail		4,823
Fuselage		123,220
Landing Gear		42,495
Nose	5,524	
Main	36,971	
Nacelles/Pylons		9,438
Nacelles	3,987	
Pylons	5,451	
Noise Treatment	0	
Propulsion System		55,719
Engines	40,142	
Thrust Reversers	6,744	
Fuel System	5,363	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,737
Auxiliary Power System	1,248	
Surface Controls	8,348	
Instruments	1,599	
Hydraulics and Pneumatics	3,890	
Electrical	4,009	
Avionics	2,400	
Furnishings	7,311	
Air-conditioning and Anti-ice	5,738	
Auxiliary Gear-Equipment	193	
Weight Empty		387,522
Operating Equipment		12,482
Operating Weight		400,004
Payload		390,000
Zero Fuel Weight		790,004
Fuel		252,206
Gross Weight		1,042,211
AMPR Weight		323,202

TABLE D-15

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-223

LGA-144- 223	OPERATING WEIGHT	400,004
Delete:		
Ramp Extensions	3,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	280	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,850	
Tiedown Rings	1,250	
Loadmasters	440	
Total	14,250	
LGA-144-223 C	OPERATING WEIGHT	385,754
Payload		404,250
ZERO FUEL WEIGHT		790,004
Fuel		252,207
GROSS WEIGHT		1,042,211

the drive-on/drive-off military requirement is maintained and the ramp slope is identical to the -200 baseline, an aircraft with a cargo floor height of 13 feet (-231) will require a much longer and consequently heavier ramp. Additionally, the system is more complex (4 ramp extension segments versus 2 for the -200 baseline), and the ramp extensions occupy more space when stowed. Figure D-11 shows the forward fuselage with ramp for the -231; a similar design is used at the aft fuselage. Figure D-12 shows the simplified main gear retraction scheme; i.e., the gear is simply retracted forward without the necessity for rotating prior to retraction as with the -200 baseline gear. As with the -200 main gear, the forward main gear is steerable and the aft main gear casters during ground maneuvering.

The landing gear weight is reduced by 3300 pounds, but longer ramp extensions add about 6400 pounds, resulting in a net gross weight increase after reoptimization of about 6000 pounds over the -200 baseline configuration.

Figure D-13 presents the footprint of the landing gear.

Tables D-16, D-17, and D-18 present the physical and performance characteristics of the -231 configuration.

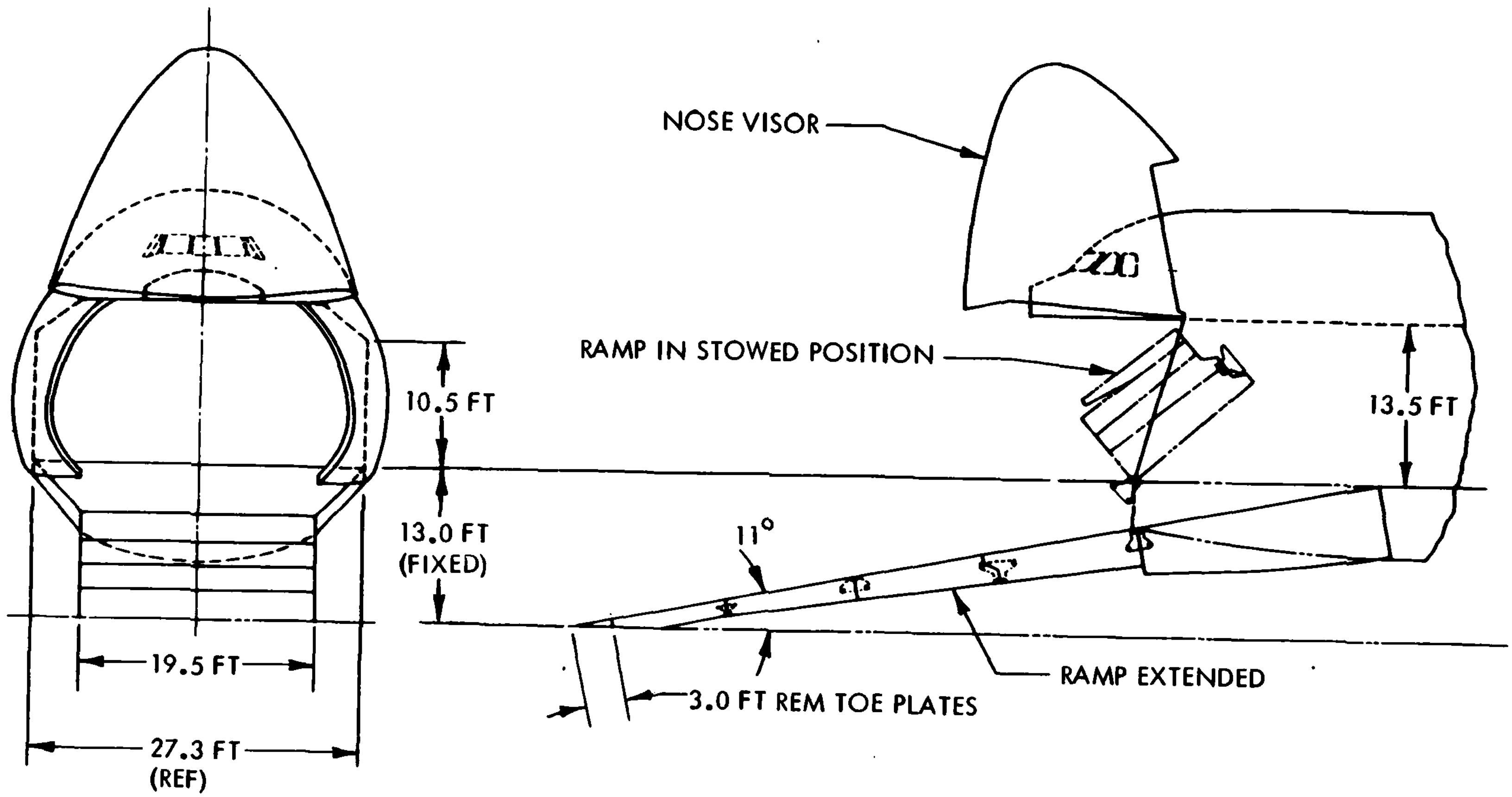


Figure D-11. LGA-144-231 Aircraft - Non-Kneeled Ramp

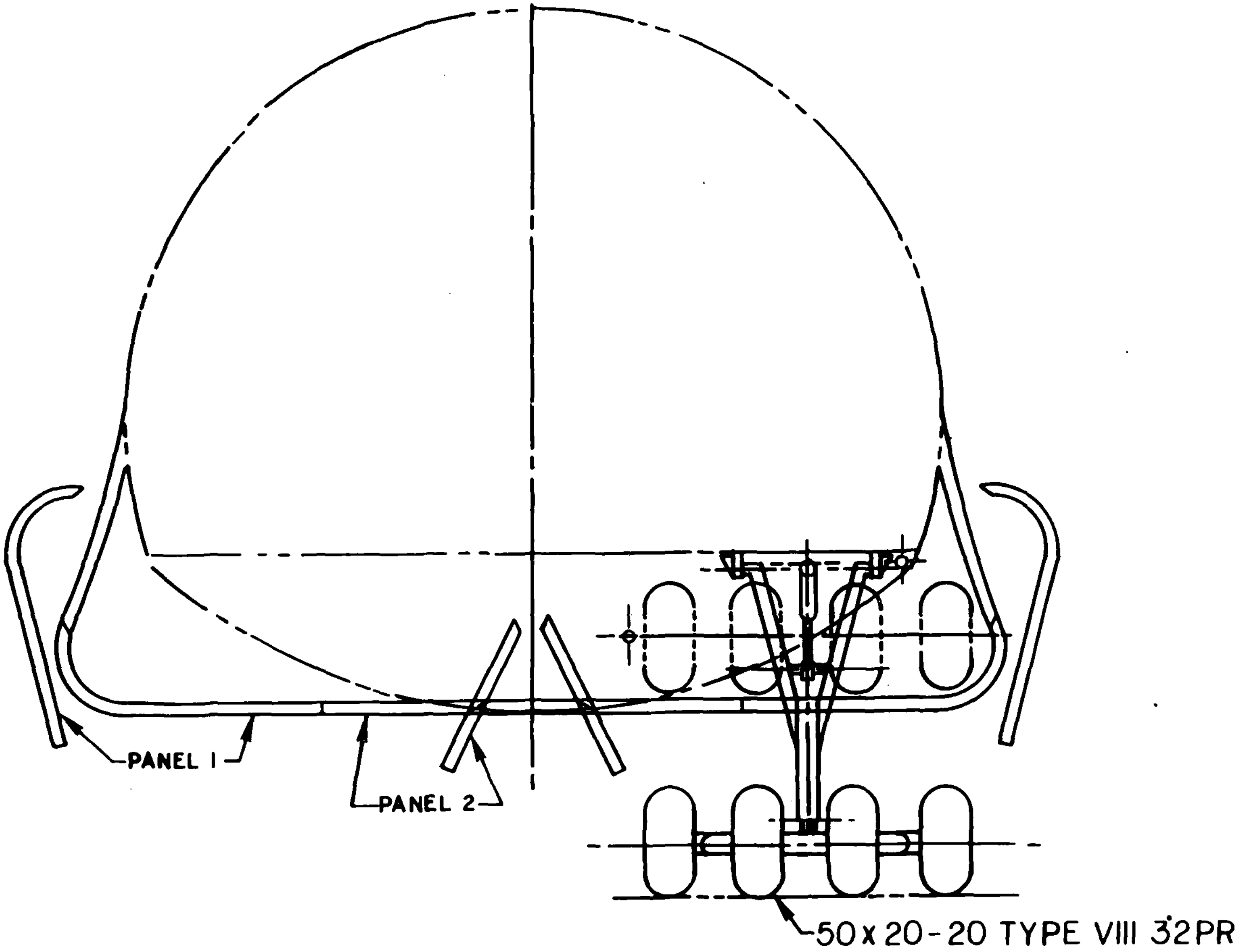


Figure D-12. Retraction Scheme - Non-Kneeling Gear (LGA-144-231)

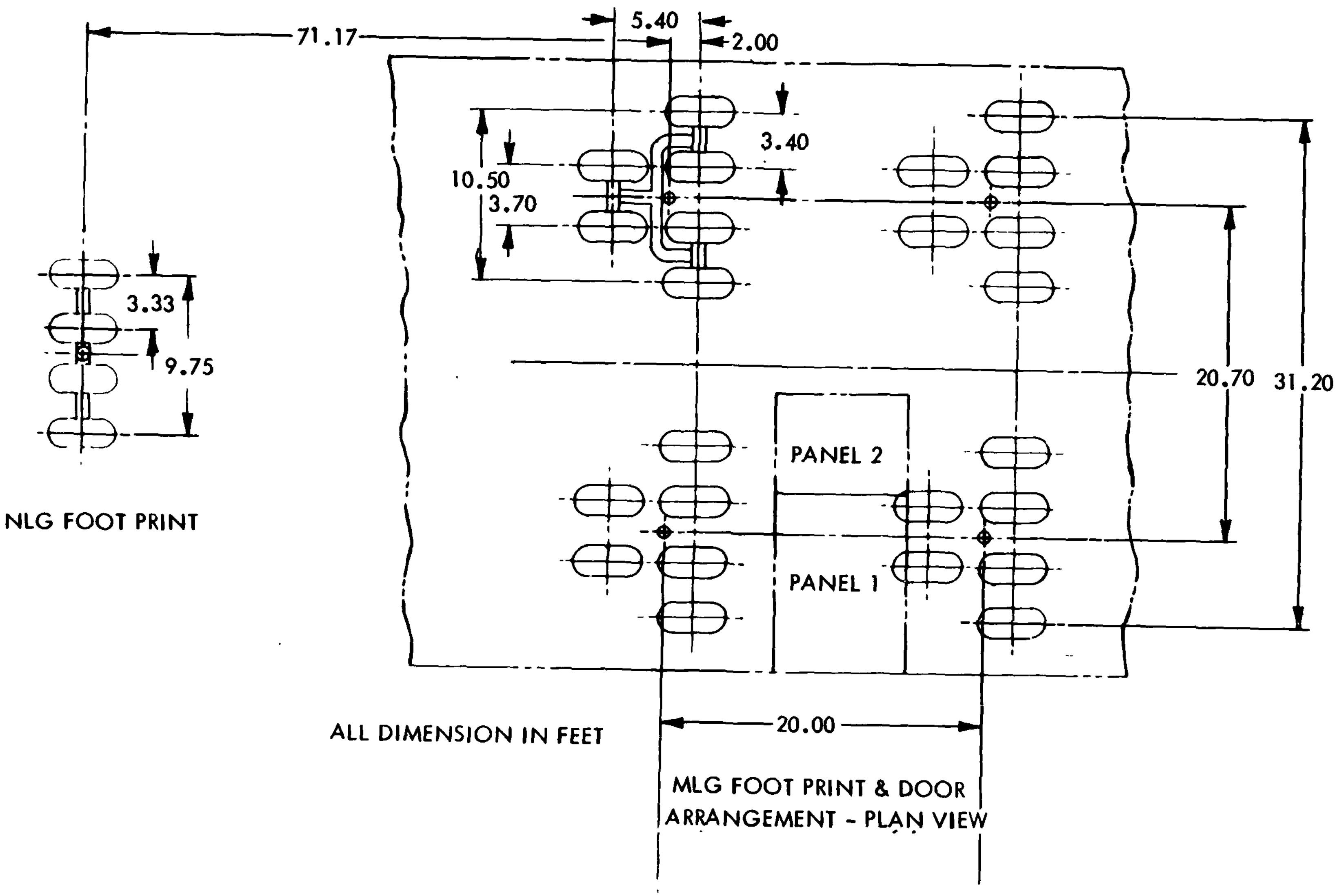


Figure D-13. Non-Kneeling Landing Gear Arrangement (LGA-144-231)

TABLE D-16

DESIGN AND PERFORMANCE DATA LGA-144-231

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,666
Pressure Volume (ft^3)	148,167
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,692	919	929
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.48	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	284	64	34
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	59,052
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	380,053
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-

TABLE D-17

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-231

ITEM	POUNDS	
Wing		107,282
Horizontal Tail		5,383
Vertical Tail		4,357
Fuselage		138,220
Landing Gear		38,635
Nose	5,023	
Main	33,613	
Nacelles/Pylons		9,221
Nacelles	3,910	
Pylons	5,311	
Noise Treatment	0	
Propulsion System		54,418
Engines	39,048	
Thrust Reversers	6,560	
Fuel System	5,340	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,745
Auxiliary Power System	1,225	
Surface Controls	8,168	
Instruments	1,604	
Hydraulics and Pneumatics	3,807	
Electrical	4,021	
Avionics	2,400	
Furnishings	7,575	
Air-conditioning and Anti-ice	5,756	
Auxiliary Gear-Equipment	188	
Weight Empty		392,262
Operating Equipment		11,837
Operating Weight		404,099
Payload		0
Zero Fuel Weight		764,099
Fuel		252,713
Gross Weight		1,016,813
AMPR Weight		330,935

TABLE D-18
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-231

LGA-144-231		OPERATING WEIGHT	404,099
Delete:			
Ramp Extensions	11,220		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	990		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,400		
Tiedown Rings	1,210		
Loadmasters	440		
Total	21,890		
LGA-144-231 C		OPERATING WEIGHT	382,209
Payload			381,890
ZERO FUEL WEIGHT			764,099
Fuel			252,714
GROSS WEIGHT			1,016,813

APPENDIX E. DESCRIPTION OF GROUP III CONFIGURATIONS

LGA-144-323 BASELINE

The -323 serves as the baseline configuration for the Group III Analyses. This configuration was derived from the -200, using a more refined takeoff routine to reoptimize the design. The takeoff routine was revised to provide the very detailed takeoff data required for the Group III design features.

Figure E-1 shows the takeoff distance characteristics of the -200 baseline using the new takeoff routine. Note that the takeoff distance over the 50-foot obstacle is lower than originally determined using the old routine. When the -323 baseline was optimized for the 9500 ft takeoff distance using the new routine, the design-point takeoff distance falls into place, as shown on Figure E-2. See Figure E-3 for a general arrangement and Tables E-1, E-2, and E-3 for the -323 performance and physical characteristics.

Figure E-4 presents the footprint and LCG III landing gear arrangement for the -323 baseline. The tires are B.F. Goodrich 50 by 20 by 20, 32 ply rating, Type VIII. The Defense Mapping Agency document (Ref E-1) provides considerable definition and details concerning the development of LCG numbers for various landing gear arrangements on rigid pavement. The following discussion provides a brief synopsis of how LCNs and LCGs are developed.

At various aircraft weights and center of gravity locations, single wheel loads are developed. A tire can be selected based on the maximum load it will see in service. With a tire load-deflection curve and footprint defined, the equivalent single wheel load (ESWL) is developed in a Lockheed computer model for various subgrade constants (K = 100, poor subgrade, and K = 300, good subgrade). These subgrades are defined in detail in Reference E-1, but the majority of airfields fall between K=100 and K=300.

When the ESWL is known, the LCN can be determined from a graph (Ref E-1) of LCN vs ESWL for various tire pressures; hence, the graph of LCN versus aircraft weight for various subgrade constants can be constructed as shown on

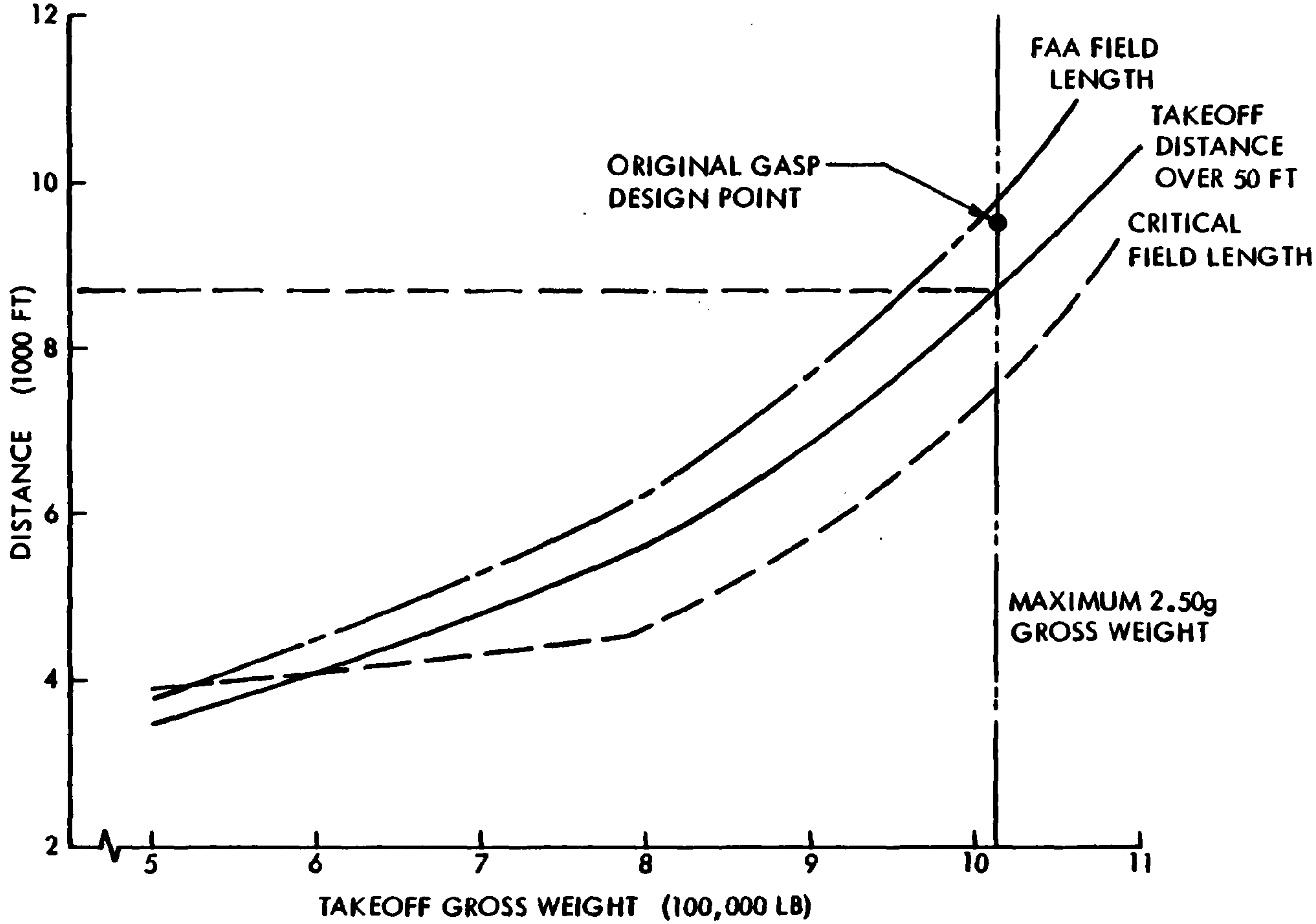


Figure E-1. Takeoff Distance Characteristics: LGA-144-200

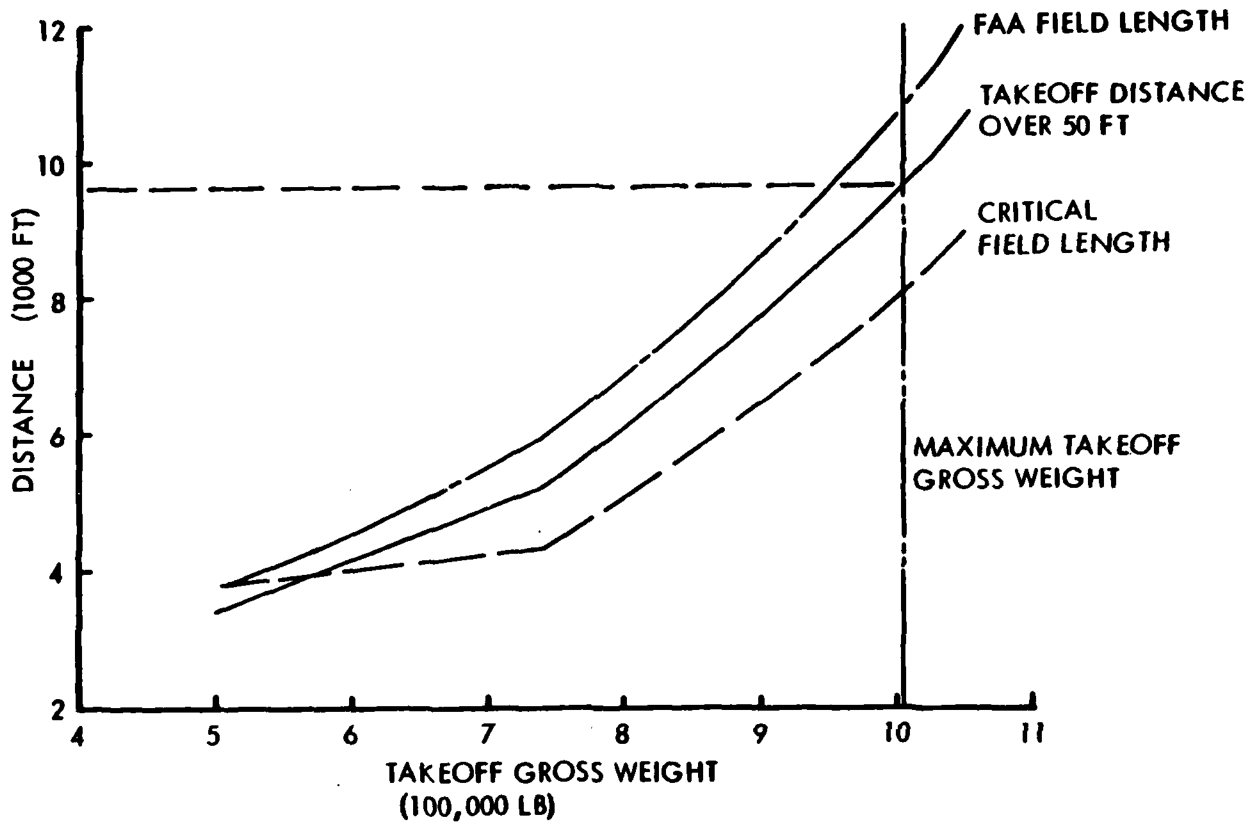


Figure E-2. Takeoff Distance Characteristics: LGA-144-323

9500 FT FIELD LENGTH

CRUISE MACH NO.	0.78
DESIGN PAYLOAD	360,000 LB
DESIGN RANGE	4,000 NM
OPERATING WT	394,000 LB
MAX GROSS WT	1,005,000 LB
ASPECT RATIO	10.28
WING LOADING	129.4 PSF
THRUST PER ENGINE	56,100 LB

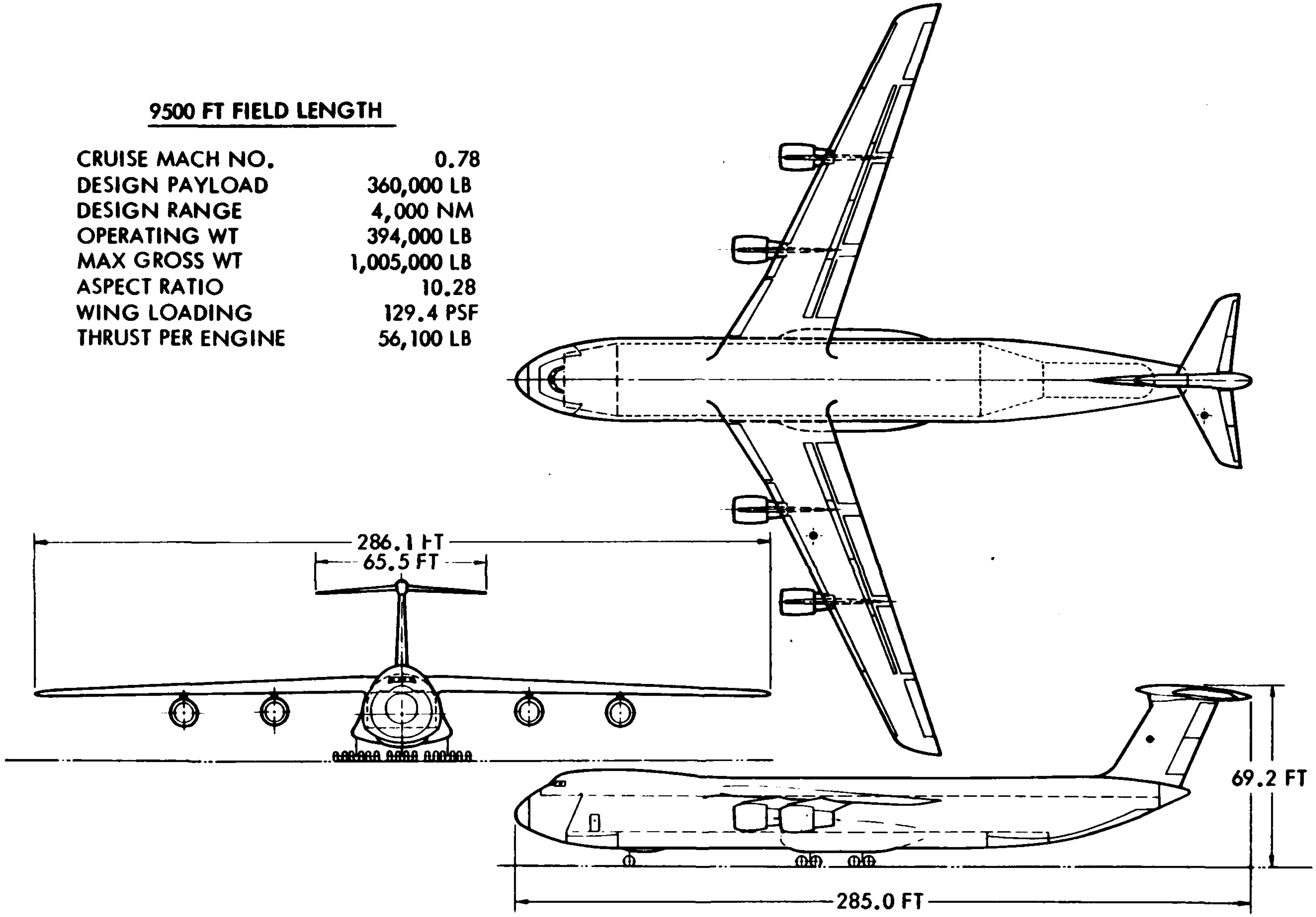


Figure E-3. LGA-144-323 General Arrangement

TABLE E-1
DESIGN AND PERFORMANCE DATA LGA-144-323

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,730
Pressure Volume (ft^3)	148,167
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,591	911	865
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.28	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	279	64	33
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	56,089
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	374,910
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,953	10,632
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE E-2

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-323

ITEM	POUNDS	
Wing		104,173
Horizontal Tail		5,330
Vertical Tail		4,134
Fuselage		131,832
Landing Gear		41,743
Nose	5,427	
Main	36,317	
Nacelles/Pylons		8,779
Nacelles	3,752	
Pylons	5,027	
Noise Treatment	0	
Propulsion System		51,815
Engines	36,831	
Thrust Reversers	6,188	
Fuel System	5,326	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,582
Auxiliary Power System	1,214	
Surface Controls	8,085	
Instruments	1,597	
Hydraulics and Pneumatics	3,768	
Electrical	3,998	
Avionics	2,400	
Furnishings	7,581	
Air-conditioning and Anti-ice	5,752	
Auxiliary Gear-Equipment	186	
Weight Empty		382,389
Operating Equipment		11,777
Operating Weight		394,166
Payload		360,000
Zero Fuel Weight		754,166
Fuel		250,509
Gross Weight		1,004,675
AMPR Weight		321,767

TABLE E-3
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-323

LGA-144- 323	OPERATING WEIGHT	394,166
Delete:		
Ramp Extensions	4,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,400	
Tiedown Rings	1,210	
Loadmasters	440	
Total	14,910	
LGA-144-323C	OPERATING WEIGHT	379,256
Payload		374,910
ZERO FUEL WEIGHT		754,166
Fuel		250,509
GROSS WEIGHT		1,004,675

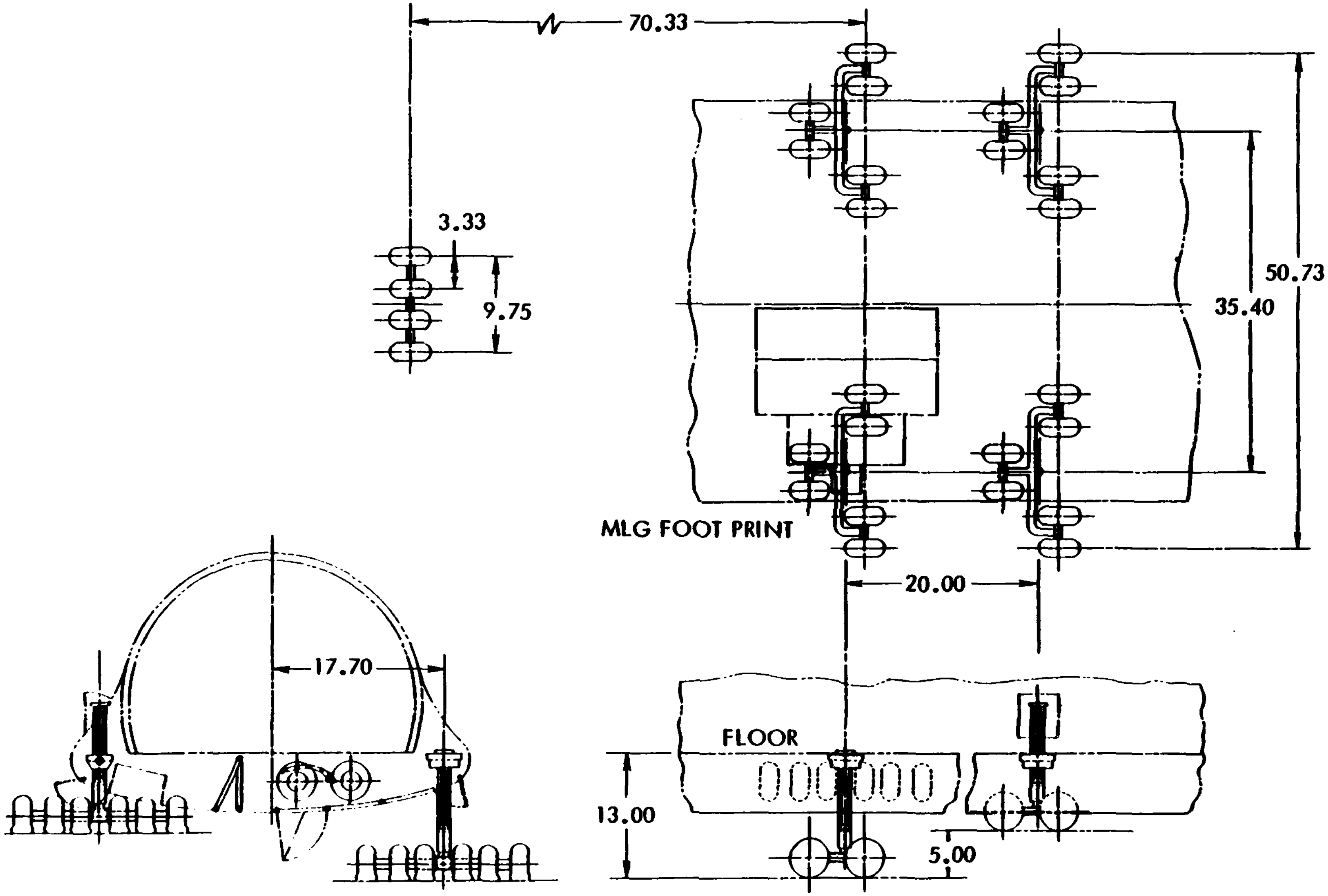


Figure E-4. Landing Gear Arrangement - LCG III Configurations

Figure E-5. Thereafter, the LCN (or LCG) can be found for the configuration if the aircraft weight is known. Note from Figure E-5 that the LCG for an aircraft at maximum takeoff gross weight is approximately one number higher than for its landing weight.

LCG II, III and IV are the ones of principal concern in this study. For reference purposes the following conversion is given:

LCG II = LCNs 76 to 100
LCG III = LCNs 51 to 75
LCG IV = LCNs 31 to 50

LGA-144-313

This option assesses the cost effectiveness implications of an aircraft designed to LCG III, but with a takeoff distance over a 50-foot obstacle of 8000 ft. Figure E-6 presents a three view of the -313 with some pertinent design data.

Figure E-7 shows the takeoff characteristics of the -313 configuration not only in terms of takeoff distance over a 50-foot obstacle, but also for FAA field length and critical field length for various aircraft weights. Tables E-4, E-5, and E-6 present performance and physical characteristics of the -313 configuration.

LGA-144-333

This option is configured with a takeoff distance over a 50-foot obstacle of 10,500 feet and a flotation of LCG III; hence, a comparison of the -313, -323, and -333 provide three data points for LCG III Configurations at takeoff distances of 8000, 9500, and 10,500 feet, respectively.

A general arrangement of the -333 configuration is shown in Figure E-8; takeoff distance characteristics are shown in Figure E-9. Tables E-7, E-8, and E-9 present performance and physical characteristics of the -333 configuration.

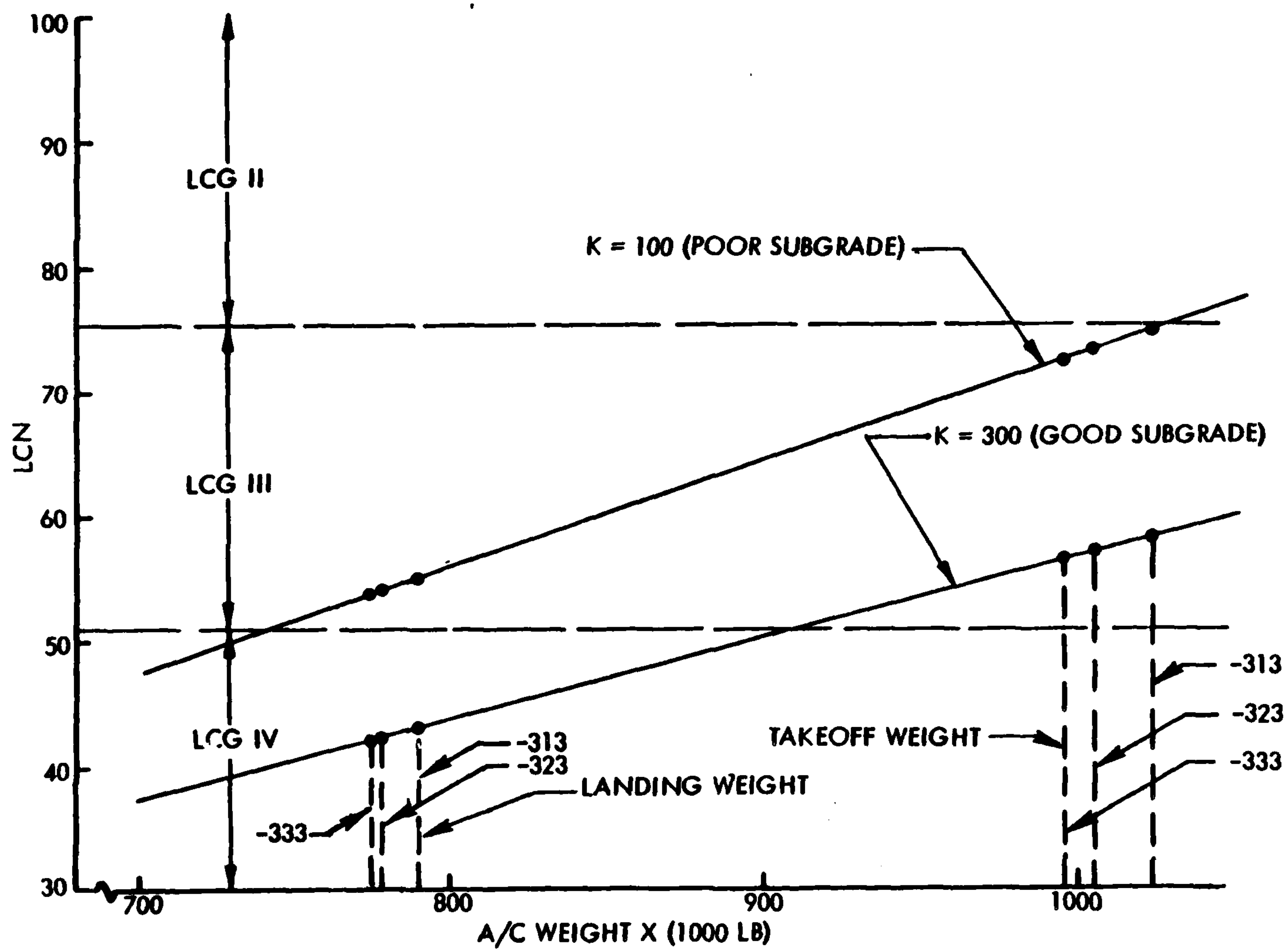


Figure E-5. LCN Characteristics - LCG III Configurations

8,000 FT FIELD LENGTH

CRUISE MACH NO.	0.78
DESIGN PAYLOAD	360,000 LB
DESIGN RANGE	4,000 NM
OPERATING WT	404,000 LB
MAX GROSS WT	1,025,000 LB
ASPECT RATIO	10.0
WING LOADING	129.4 PSF
THRUST PER ENGINE	64,900 LB

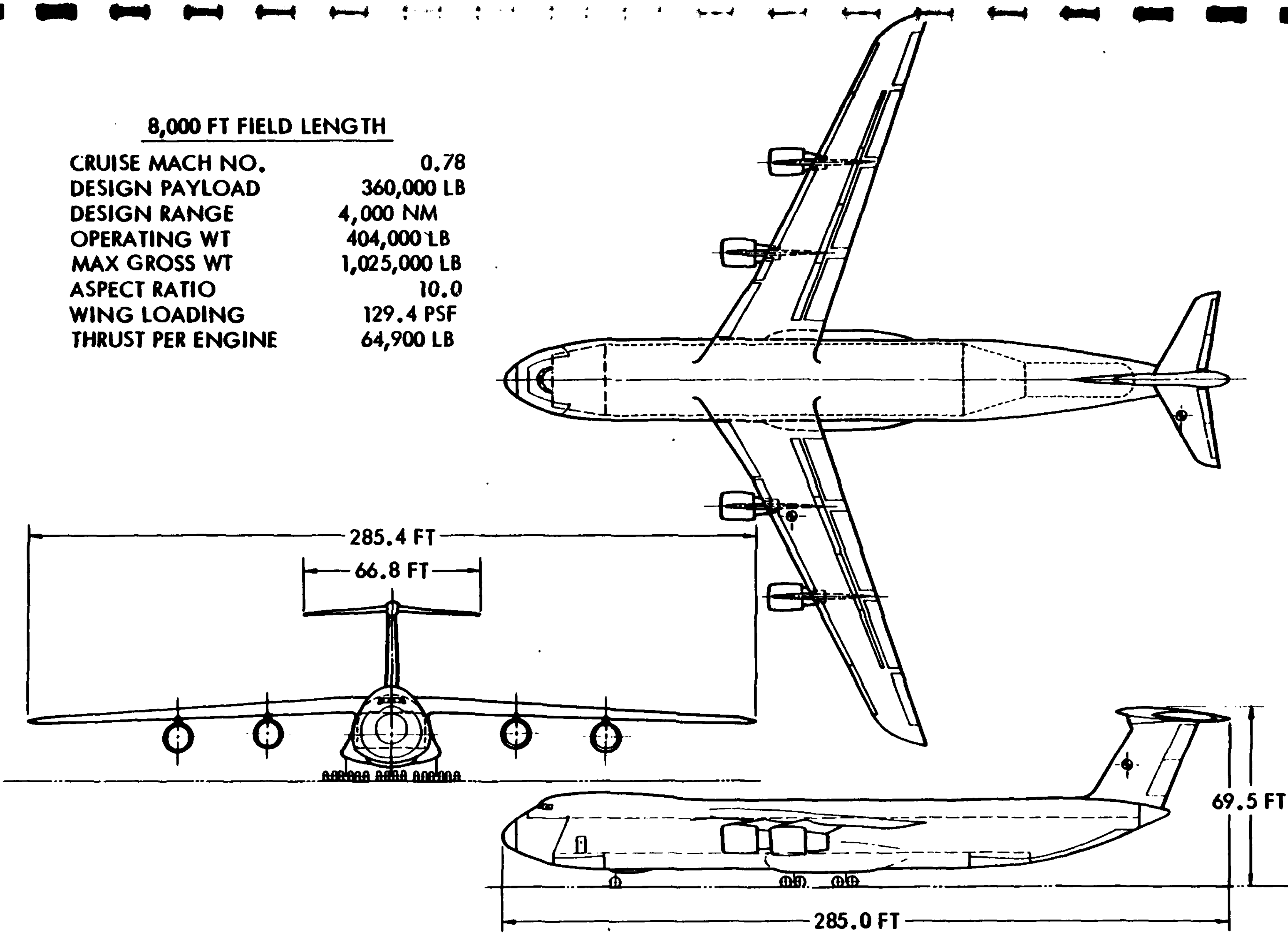


Figure E-6. LGA-144-313 General Arrangement

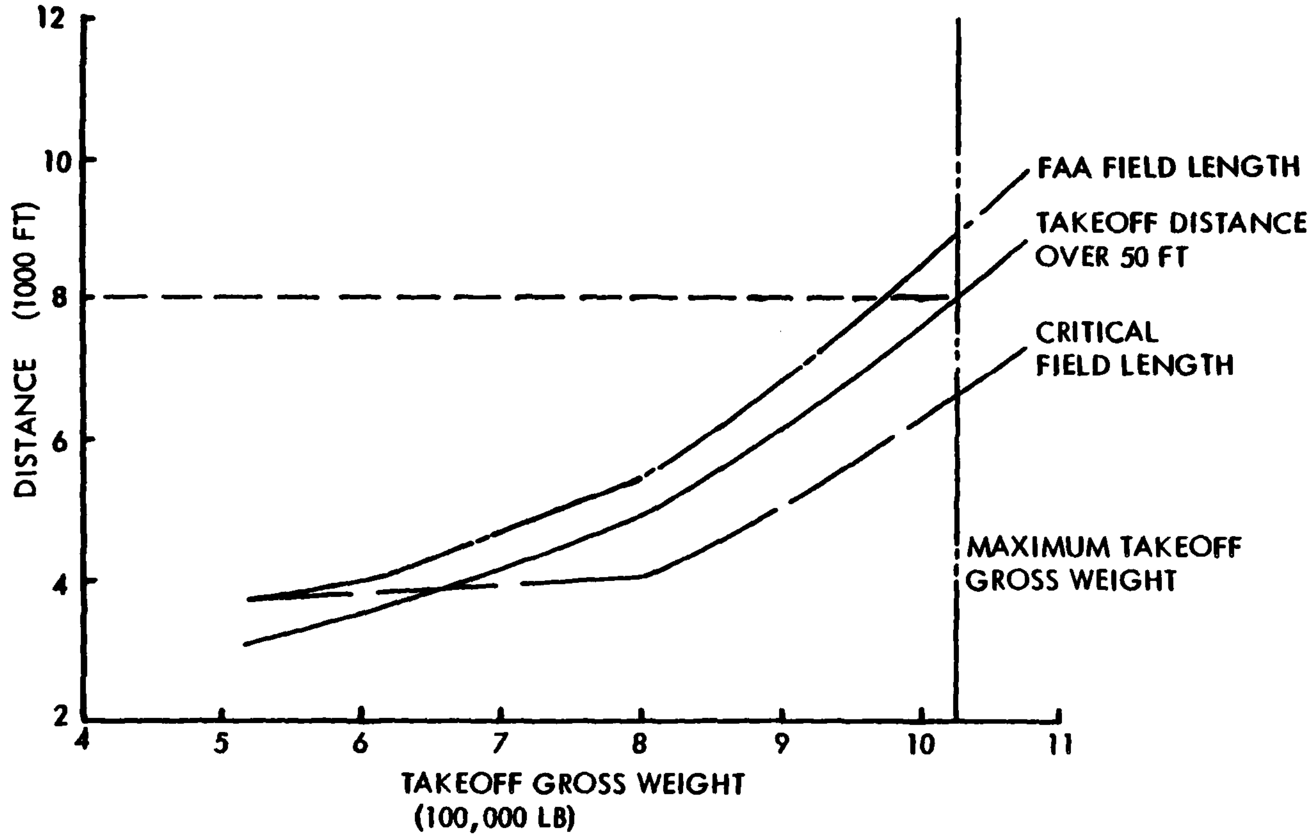


Figure E-7. Takeoff Distance Characteristics: LGA-144-313

TABLE E-4
DESIGN AND PERFORMANCE DATA LGA-144-313

FUSELAGE GEOMETRY

Length (ft)	259
Wetted Area (ft^2)	21,730
Pressure Volume (ft^3)	148,167
Cargo Compt L x W x H (ft)	184.6 x 23.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY

	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,765	945	1,024
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.00	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	279	65	36
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	64,929
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE

	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	374,910
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	8,000	-
Critical field length/ FAA field length (ft)	6,629	8,923
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE E-5

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-313

ITEM	POUNDS	
Wing		103,450
Horizontal Tail		5,504
Vertical Tail		4,671
Fuselage		131,993
Landing Gear		42,057
Nose	5,467	
Main	36,590	
Nacelles/Pylons		10,097
Nacelles	4,220	
Pylons	5,877	
Noise Treatment	0	
Propulsion System		59,705
Engines	43,487	
Thrust Reversers	7,306	
Fuel System	5,442	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,833
Auxiliary Power System	1,233	
Surface Controls	8,239	
Instruments	1,596	
Hydraulics and Pneumatics	3,839	
Electrical	3,995	
Avionics	2,400	
Furnishings	7,581	
Air-conditioning and Anti-ice	5,760	
Auxiliary Gear-Equipment	190	
Weight Empty		392,311
Operating Equipment		12,011
Operating Weight		404,322
Payload		360,000
Zero Fuel Weight		764,322
Fuel		260,836
Gross Weight		1,025,158
AMPR Weight		324,872

TABLE E-6
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-313

LGA-144-313	OPERATING WEIGHT	404,322
Delete:		
Ramp Extensions	4,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,400	
Tiedown Rings	1,210	
Loadmasters	440	
Total	14,910	
LGA-144-313 C	OPERATING WEIGHT	389,412
Payload		374,910
ZERO FUEL WEIGHT		764,322
Fuel		260,836
GROSS WEIGHT		1,025,158

10,500 FT FIELD LENGTH	
CRUISE MACH NO.	0.78
DESIGN PAYLOAD	360,000 LB
DESIGN RANGE	4,000 NM
OPERATING WT	390,000 LB
MAX GROSS WT	996,000 LB
ASPECT RATIO	10.75
WING LOADING	135.6 PSF
THRUST PER ENGINE	53,600 LB

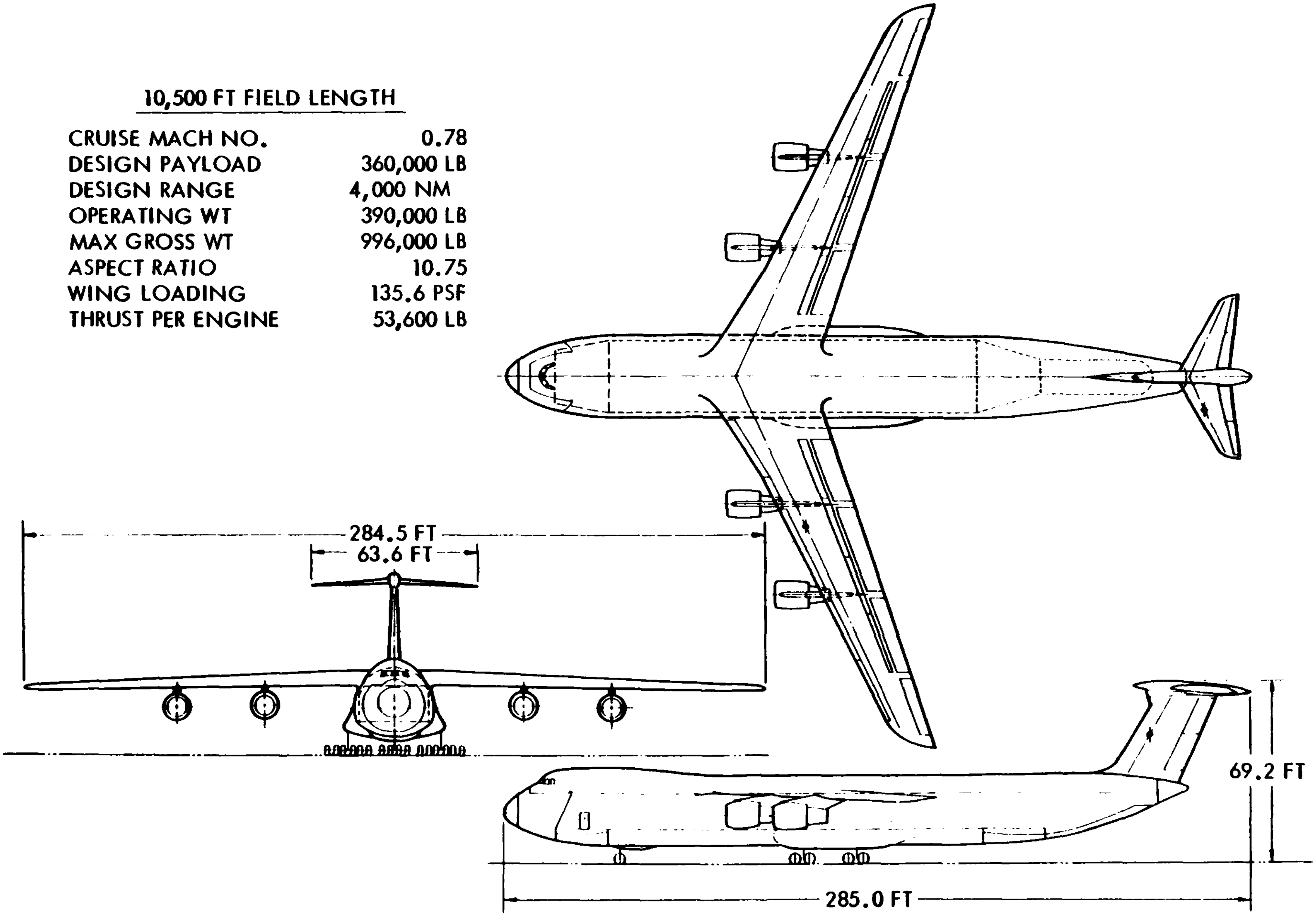


Figure E-8. LGA-144-333 General Arrangement

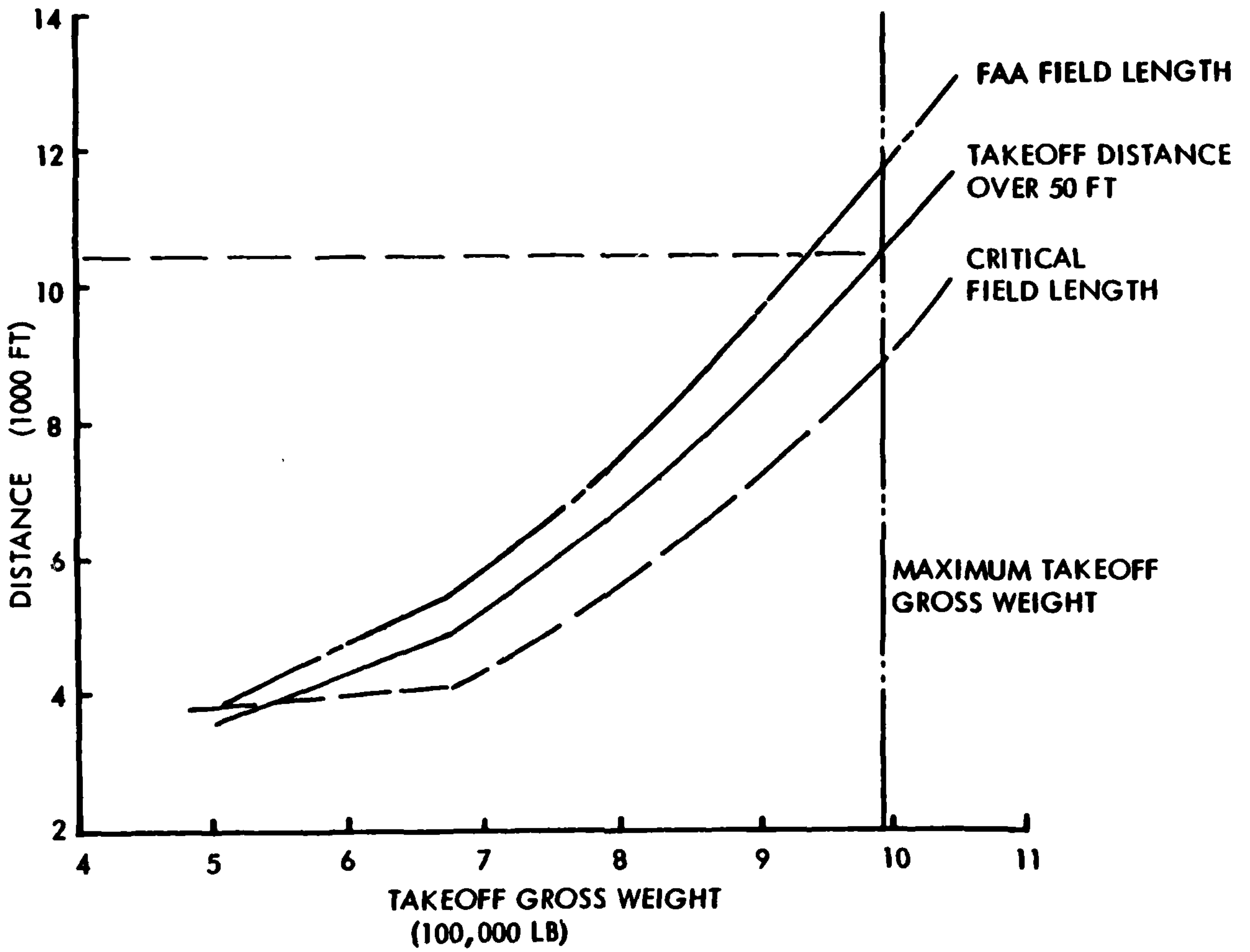


Figure E-9. Takeoff Distance Characteristics: LGA-144-333

TABLE E-7

DESIGN AND PERFORMANCE DATA LGA-144-333

FUSELAGE GEOMETRY

Length (ft)	259
Wetted Area (ft^2)	21,730
Pressure Volume (ft^3)	148,167
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,182	857	836
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.75	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	278	62	32
Wing Loading (lb/ft^2)	135.57	-	-

ENGINE

Thrust (Sea Level Static - lb)	53,593
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	374,910
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	10,500	-
Critical field length/ FAA field length (ft)	8,823	11,772
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE E-8

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-333

ITEM	POUNDS	
Wing		104,394
Horizontal Tail		5,097
Vertical Tail		4,029
Fuselage		131,769
Landing Gear		41,621
Nose	5,411	
Main	36,210	
Nacelles/Pylons		8,406
Nacelles	3,617	
Pylons	4,789	
Noise Treatment	0	
Propulsion System		49,528
Engines	34,977	
Thrust Reversers	5,876	
Fuel System	5,205	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,310
Auxiliary Power System	1,207	
Surface Controls	7,920	
Instruments	1,595	
Hydraulics and Pneumatics	3,691	
Electrical	3,991	
Avionics	2,400	
Furnishings	7,581	
Air-conditioning and Anti-ice	5,742	
Auxiliary Gear-Equipment	184	
Weight Empty		379,154
Operating Equipment		11,292
Operating Weight		390,446
Payload		360,000
Zero Fuel Weight		750,446
Fuel		246,004
Gross Weight		996,450
AMPR Weight		320,452

TABLE E-9
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-333

LGA-144-333		OPERATING WEIGHT	390,446
Delete:			
Ramp Extensions	4,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	430		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,400		
Tiedown Rings	1,210		
Loadmasters	440		
Total	14,910		
LGA-144-333 C		OPERATING WEIGHT	375,536
Payload			374,910
ZERO FUEL WEIGHT			750,446
Fuel			246,004
GROSS WEIGHT			996,450

LGA-144-322

The -322 and -332 were created to allow assessment of LCG II flotation. The only configurational difference between these aircraft and the -323 baseline is the landing gear arrangement. Figure E-10 shows a three view of the LCG II landing gear with its associated footprint. Note the main landing gear is now a four-wheel bogie, and the tires are B.F. Goodrich 52 by 20.5 by 20, 36 ply rating, somewhat larger than those on the -323 baseline configuration. Note also the simplified retraction scheme for the main landing gear; the gear retracts directly inboard and does not require the 90° rotation, as does the -323 gear.

The LCG characteristics for the -322 are shown in Figure E-11. At maximum takeoff gross weight, the larger portion of the distance between poor subgrade and good subgrade lies in the LCG II band. As with all Group III Takeoff Distance/LCG Flotation options, the LCG at landing weight is approximately one group lower than the takeoff weight LCG; i.e., LCG II at takeoff weight becomes LCG III at landing weight.

Tables E-10, E-11, and E-12 present performance and physical characteristics of the -322 configuration.

LGA-144-332

As with -322, the -332 configuration was created to assess LCG II flotation. However, the -332 has a takeoff distance over a fifty foot obstacle of 10,500 feet. This allows direct comparison with the -333 which has a LCG III, but a takeoff distance of 10,500 feet.

Tables E-13, E-14, and E-15 present performance and physical characteristics of the -332 Configuration.

LGA-144-353

All configurations examined in the Design Option Study except the -353 are essentially military designs from the standpoint of noise and one-engine-out

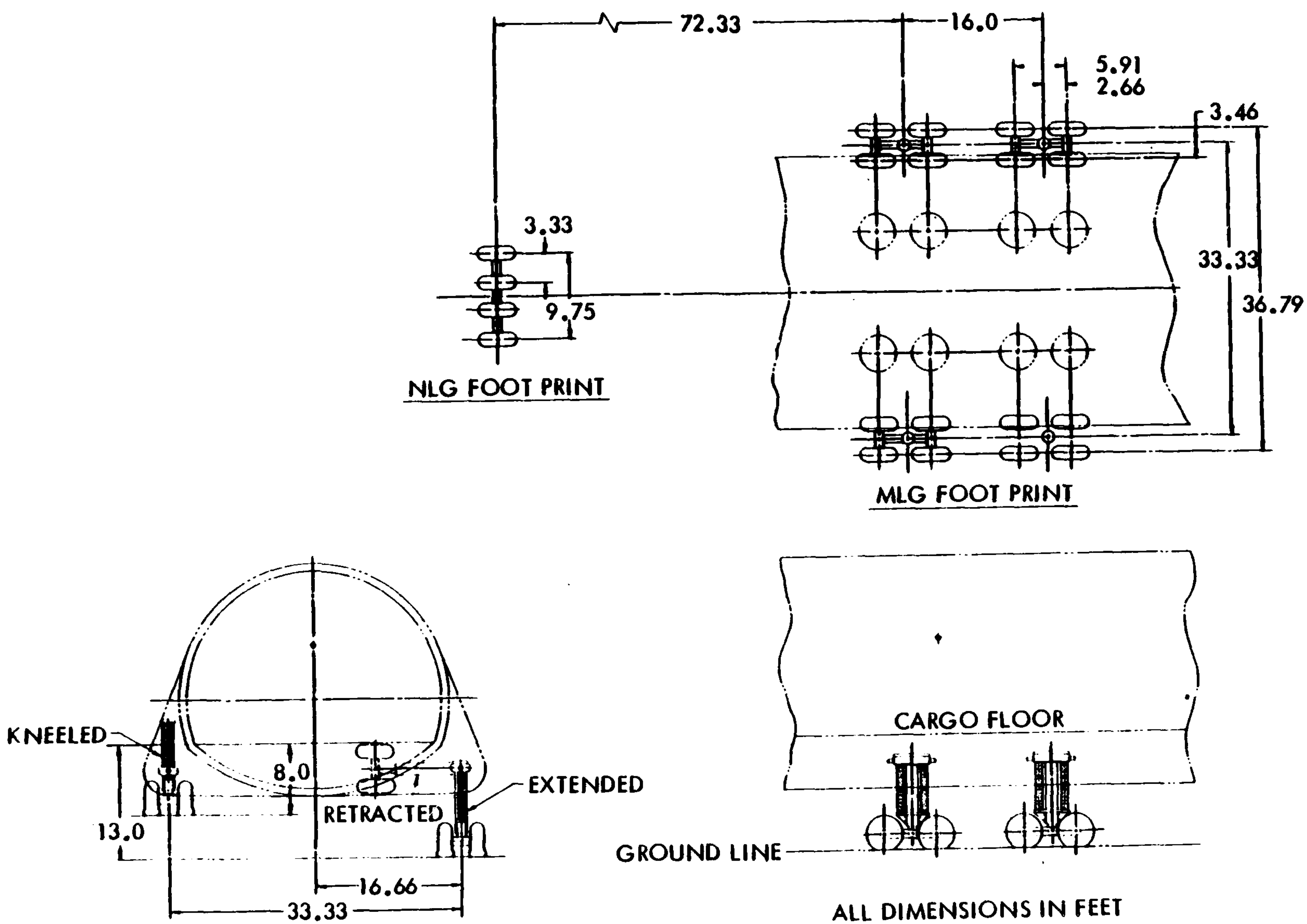


Figure E-10. LCG II Landing Gear Arrangement

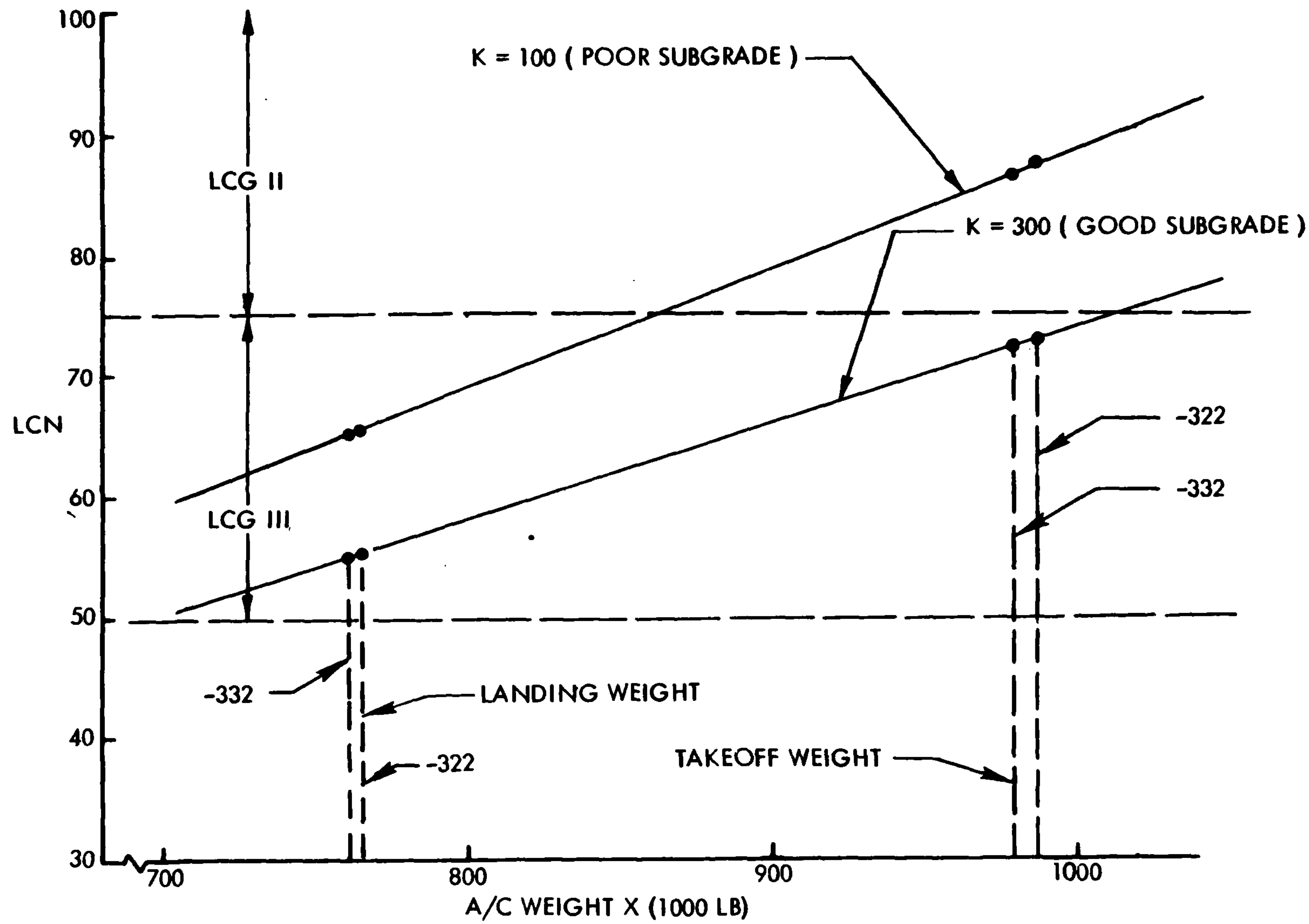


Figure E-11. LCN Characteristics - LCG II Configurations

TABLE E-10
DESIGN AND PERFORMANCE DATA LGA-144-322

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,430
Pressure Volume (ft^3)	148,167
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,464	910	826
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.28	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	277	64	32
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	55,230
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	374,910
Range (nm)	4,000	3,507
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,944	10,631
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	II	II

TABLE E-11

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-322

ITEM	POUNDS	
Wing		101,972
Horizontal Tail		5,301
Vertical Tail		3,988
Fuselage		129,563
Landing Gear		34,741
Nose	4,516	
Main	30,224	
Nacelles/Pylons		8,650
Nacelles	3,706	
Pylons	4,945	
Noise Treatment	0	
Propulsion System		51,023
Engines	36,192	
Thrust Reversers	6,080	
Fuel System	5,280	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,359
Auxiliary Power System	1,199	
Surface Controls	7,979	
Instruments	1,594	
Hydraulics and Pneumatics	3,718	
Electrical	3,986	
Avionics	2,400	
Furnishings	7,552	
Air-conditioning and Anti-ice	5,749	
Auxiliary Gear-Equipment	183	
Weight Empty		369,597
Operating Equipment		11,651
Operating Weight		381,248
Payload		360,000
Zero Fuel Weight		741,248
Fuel		246,511
Gross Weight		987,759
AMPR Weight		313,057

TABLE E-12
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-322

LGA-144-322	OPERATING WEIGHT	381,248
Delete:		
Ramp Extensions	4,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	430	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,400	
Tiedown Rings	1,210	
Loadmasters	440	
Total	14,910	
LGA-144-322C	OPERATING WEIGHT	366,338
Payload		374,910
ZERO FUEL WEIGHT		741,248
Fuel		246,511
GROSS WEIGHT		987,759

TABLE E-13

DESIGN AND PERFORMANCE DATA LGA-144-332

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,430
Pressure Volume (ft^3)	148,167
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,065	857	879
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.75	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	276	62	33
Wing Loading (lb/ft^2)	135.57	-	-

ENGINE	
Thrust (Sea Level Static - lb)	52,691
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	374,910
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	10,500	-
Critical field length/ FAA field length (ft)	8,802	11,754
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	II	II

TABLE E-14

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-332

ITEM	POUNDS	
Wing		102,241
Horizontal Tail		5,071
Vertical Tail		4,158
Fuselage		129,506
Landing Gear		34,522
Nose	4,488	
Main	30,034	
Nacelles/Pylons		8,271
Nacelles	3,569	
Pylons	4,703	
Noise Treatment	0	
Propulsion System		48,708
Engines	34,310	
Thrust Reversers	5,764	
Fuel System	5,164	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,099
Auxiliary Power System	1,192	
Surface Controls	7,819	
Instruments	1,592	
Hydraulics and Pneumatics	3,644	
Electrical	3,979	
Avionics	2,400	
Furnishings	7,552	
Air-conditioning and Anti-ice	5,740	
Auxiliary Gear-Equipment	181	
Weight Empty		366,577
Operating Equipment		11,182
Operating Weight		377,759
Payload		360,000
Zero Fuel Weight		737,759
Fuel		242,602
Gross Weight		980,360
AMPR Weight		312,032

TABLE E-15
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-332

LGA-144-332		OPERATING WEIGHT	377,759
Delete:			
Ramp Extensions	4,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	430		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,400		
Tiedown Rings	1,210		
Loadmasters	440		
Total	14,910		
LGA-144-332C		OPERATING WEIGHT	362,849
Payload			374,910
ZERO FUEL WEIGHT			737,759
Fuel			242,601
GROSS WEIGHT			980,360

climb gradients; i.e., no noise requirements were imposed on the designs and the engine-out climb gradient was specified to the military two and one-half percent. The analysis of this option determined the impact of meeting the FAR Part 36 noise requirement in conjunction with meeting the three percent climb gradient with one engine out. The remainder of this section is a discussion of the requirements and the methodology used for estimating the noise levels.

FAR Part 36 Noise Requirements - For certification, aircraft noise is specified as effective perceived noise level (EPNL) in decibels, in units of EPNdB. Final EPNL values are derived from noise tapes recorded at specified measurement points during takeoffs and landings under standard conditions. The tape is processed by a computer through the steps listed below. A similar process, with predicted noise characteristics and flight paths instead of real tapes, is used to estimate EPNLs during aircraft design.

1. Spectra of sound pressure level (SPL) vs frequency are extracted at half-second intervals. (Coarser intervals are used in estimation.)

2. It has been found that frequencies toward the upper end of the audible range are more annoying than lower frequencies. The spectra are, therefore, weighted in accordance with the relative annoyance of each frequency. Each spectrum is then integrated to obtain its perceived noise level (PNL).

3. Discrete tones (SPLs that project above adjacent segments of the spectrum) cause further annoyance. Correction for this effect yields the tone-corrected PNL, or PNLT. The maximum value of PNLT is the main determinant of EPNL.

4. The PNLT history at the measurement point is integrated over time to account for the duration of the high noise levels. Adding the duration correction to the peak PNLT yields EPNL.

EPNL limits are specified at three measurement points:

- Takeoff Flyover - On the runway centerline 21,325 ft from brake release. Thrust cutback ahead of the measurement point can be used to reduce measurement point noise, providing the height is at least 210 meters and the cutback thrust permits a 4 percent climb on all engines and level flight with one engine out.

- Takeoff Sideline - On a 1476-ft offset from the runway centerline, at the point of maximum EPNL. Because of extra sound attenuation near the ground, maximum sideline EPNL is reached when the aircraft is several hundred feet high. The minimum distance from the aircraft to the sideline then begins to increase rapidly, making EPNL fall off at points farther down the sideline.

- o Landing Approach - On the runway centerline 6252 from the assumed obstacle at the end of the runway.

Although lower limits apply to smaller aircraft, the aircraft considered in this study are big enough to be up against the EPNL limit ceilings: 106 EPNdB at takeoff flyover, 103 EPNdB at takeoff sideline, and 105 EPNdB at landing approach. All three limits must be met, except that noise greater than the limits of up to 3 EPNdB at a measurement point can be offset by noise less than the limits at the others. See Figures E-12 and E-13 for measurement points and limits.

EPNL Prediction Program - The program used for predicting EPNL requires two kinds of input:

- o Flight Path - Horizontal distance, height, and speed throughout the takeoff or approach; location of the measurement point.
- o Emitted Noise Characteristics - SPL spectra at a common radius from the aircraft and at a number of angles from its forward centerline. (Noise sources are highly directional.) If sources such as the jet and fan are input individually, the program combines them to obtain emitted spectra for the whole aircraft.

As each successive angle points at the measurement point, the program calculates the distance to the measurement point and sends the emitted spectrum through the distance, applying corrections for spherical spreading, atmospheric absorption, Doppler shift, and ground reflection. The sequence of calculated spectra received at the measurement point is processed like spectra from a tape of an actual flight, and an EPNL is derived as previously described.

Emitted Spectra - The steps from input spectra to EPNL involve accepted practice. The accuracy of an EPNL prediction depends mainly on the quality of the input spectra. Spectra measured at a ground test stand with the selected engine or a near predecessor, with flight-type noise treatment, are used if available. Even these spectra must be modified, however, to arrive at the spectra emitted in flight. Forward speed reduces jet noise by decreasing the shear intensity in the jet mixing layer and reduces fan noise by eliminating ground-induced turbulence and vortices in the inlet. These effects are appreciable but are not firmly established.

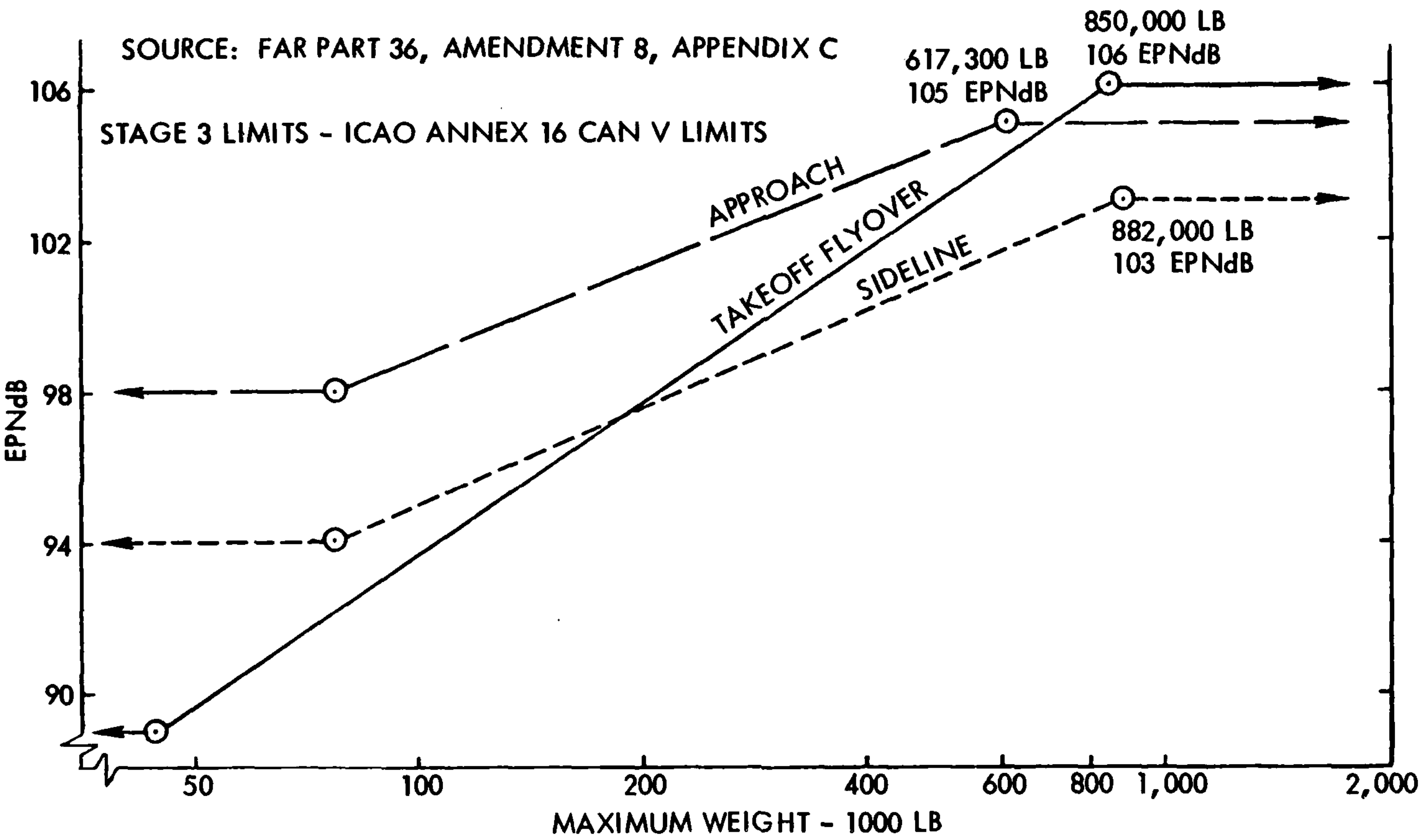


Figure E-12. FAR Part 36 Noise Limit

SOURCE: FAR PART 36, AMENDMENT 8, APPENDIX C

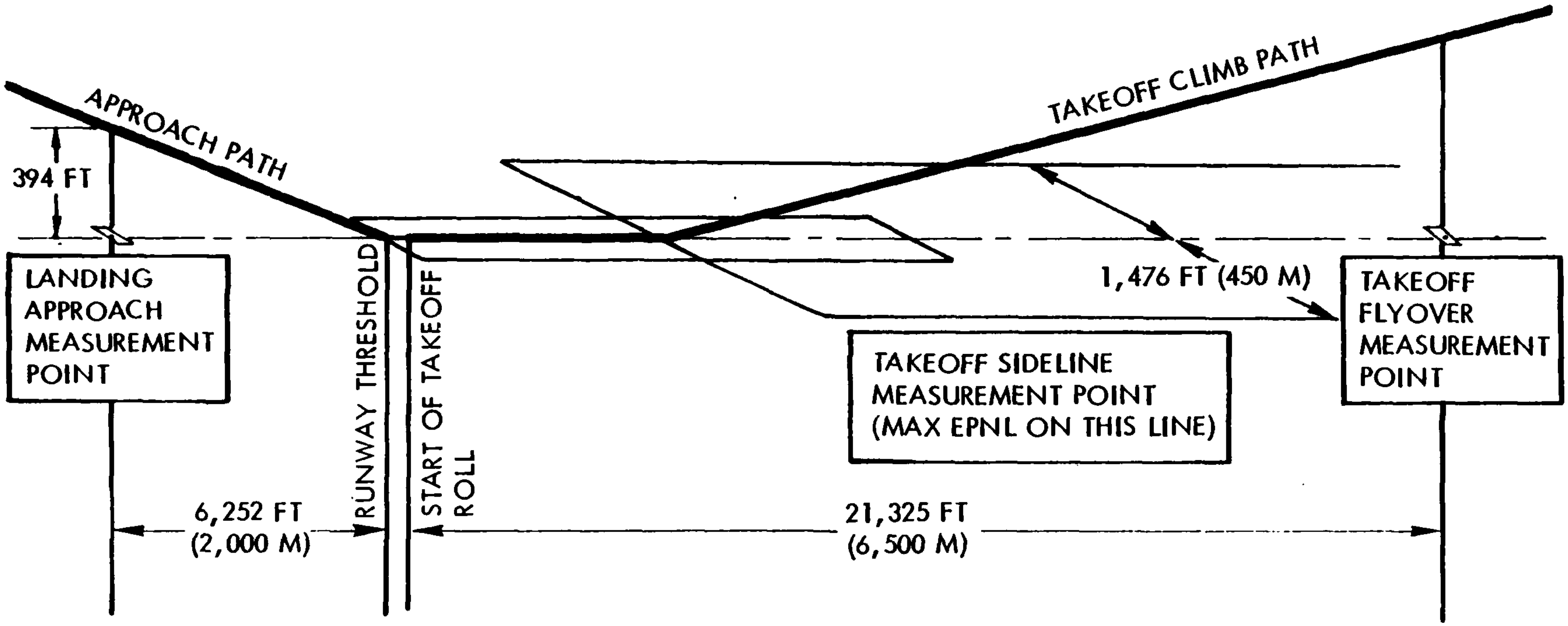


Figure E-13. FAR Part 36 Noise Measurements

Since a paper engine, the Pratt & Whitney STF477, was used in the study, an attempt was made to synthesize engine noise by methods based on the dimensional and gasdynamics properties of the component noise sources — fan, combustor, turbine, and jet — plus the effects of acoustic liners. Such methods, which are largely empirical, have been developed by industry and government organizations during the past ten years. NASA/Langley's Aircraft Noise Prediction Program (ANOPP) is the most ambitious effort. It was found, however, that the prediction gave a poor match to the measured noise of existing engines.

The approach finally adopted assumes that the noise of forthcoming turbofan engines will be similar to the noise of current high-bypass-ratio engines when both are scaled to the same thrust and installed in similar hardwall or noise-treated nacelles. Major noise reduction measures appeared about ten years ago — lower jet velocities, treated ducts, fan inlets without guide vanes or blow-in doors, and a wide spacing between the fan rotor and the exit guide vanes. No comparable improvements are assumed since none are now in prospect. For preliminary design purposes, turbofan engine noise is a mature art. (Tailored test programs and more detailed and rigorous analyses will continue to be required as an aircraft moves toward production.)

Measured test stand spectra for an existing high-bypass-ratio engine both in a hardwall nacelle and in a treated nacelle were scaled as required for the present study, corrected for forward speed effects, and used as the input spectra for the EPNL prediction program. The weight and performance loss caused by the noise suppression treatment in the STF477 inlet and exhaust ducts was estimated from data on the same engine. The EPNLs of all of the wide-bodied transports were subsequently correlated in a separate effort, the results of which support the validity of approach used herein.

<u>Results</u> - The -323, which meets neither the noise nor the engine-out climb requirements of the FARs, was the starting point. The next three aircraft designed (-343A, -353A, and -363A) meet only the climb requirement. They show how design field length affect noise. The last aircraft (-353B), meets the civil requirements in both respects.

Table E-16 illustrates the noise analysis results for all these configurations and indicates that the -353B aircraft meets the noise limits. Using thrust cutback to reduce takeoff flyover measurement point noise, the mean difference between prediction and limit is the average of -3.6, -3.9, and -0.4, or -2.6 EPNdB. Given the uncertainty of aircraft noise prediction, especially with a paper engine, this is a modest margin. The ACMA can probably meet the limits, but noise will need close attention throughout the development program. Table E-17, E-18, and E-19 present performance and physical characteristics of the -353 configuration. Table E-16 illustrates several other aspects of the noise of this class of aircraft:

- Treatment brings approach noise down by about 10 EPNdB but is less effective at takeoff. The jet, which cannot be treated, is a significant noise source at takeoff. The main source on approach is the fan, which can be treated effectively by tuning the fan inlet and exhaust duct liners to the fan blade passage frequency.

- The cutback option can be used on all of these aircraft. It reduces takeoff flyover noise by just under one EPNdB.

- As design field length increases, takeoff flyover noise increases because the aircraft is lower at the 21,324-ft measurement point. The engines are smaller but distance is a stronger variable than thrust. In contrast, takeoff sideline noise decreases because the engines are smaller and the distance from the measurement point to the aircraft is constant.

TABLE E-16
EFFECTS OF MEETING CIVIL NOISE AND ENGINE-OUT CLIMB REQUIREMENTS

AIRCRAFT CONFIGURATION		-323		-343A		-353A		-363A		-353B	
DESIGN FIELD LENGTH, FT OVER 50 FOOT OBSTACLE		9500		8000		9500		10500		9500	
ENGINE-OUT CLIMB GRADIENT		2.5%		3.0%		3.0%		3.0%		3.0%	
NACELLE		HARDWALL		HARDWALL		HARDWALL		HARDWALL		TREATED	
TOGW, LB		1.0047×10^6		1.0272×10^6		1.0077×10^6		0.996×10^6		1.0161×10^6	
RATED THRUST, LB		56100		64900		56900		55100		57700	
ALTITUDE AT TAKEOFF FLYOVER MEASUREMENT POINT, NO CUTBACK, FT		911		1186		955		842		964	
EPNL'S, EPNdB	LIMIT	PREDICTED	Δ	PREDICTED	Δ	PREDICTED	Δ	PREDICTED	Δ	PREDICTED	Δ
TAKEOFF FLYOVER, NO CUTBACK	106.0	109.0	+3.0	107.3	+1.3	108.5	+2.5	109.4	+3.4	104.5	-1.5
TAKEOFF FLYOVER, WITH CUTBACK	106.0	108.2	+2.2	106.4	+0.4	107.8	+1.8	108.7	+2.7	102.4	-3.6
TAKEOFF SIDELINE	103.0	102.8	-0.2	103.1	+0.1	102.7	-0.3	102.5	-0.5	99.1	-3.9
LANDING APPROACH	105.0	115.5	+10.5	116.0	+11.0	115.4	+10.4	115.3	+10.3	104.6	-0.4

Δ EPNL = PREDICTED - LIMIT

• ESTIMATED PENALTIES - 800 LB/NACELLES; 0.5% SFC

TABLE E-17

DESIGN AND PERFORMANCE DATA LGA-144-353

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,730
Pressure Volume (ft^3)	148,167
Cargo Compt L X W X H (ft)	184.6 x 27.3 x 13.5
Forward Aperture Width (ft)	19.5
Aft Aperture Width (ft)	13.0

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,681	917	890
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.50	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	284	64	33
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	57,715
TSFC (Cruise lb/lb/hr)	0.596

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	360,000	374,910
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,985	10,613
Second segment climb gradient (%)	3.0	3.0
Landing gear flotation (LCG)	III	III

TABLE E-18

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-353

ITEM	POUNDS	
Wing		106,980
Horizontal Tail		5,374
Vertical Tail		4,226
Fuselage		131,941
Landing Gear		41,955
Nose	5,454	
Main	36,501	
Nacelles/Pylons		12,442
Nacelles	3,839	
Pylons	5,403	
Noise Treatment	3,200	
Propulsion System		53,905
Engines	38,151	
Thrust Reversers	6,947	
Fuel System	5,337	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,739
Auxiliary Power System	1,224	
Surface Controls	8,161	
Instruments	1,604	
Hydraulics and Pneumatics	3,803	
Electrical	4,022	
Avionics	2,400	
Furnishings	7,581	
Air-conditioning and Anti-ice	5,755	
Auxiliary Gear-Equipment	188	
Weight Empty		391,562
Operating Equipment		11,822
Operating Weight		403,384
Payload		360,000
Zero Fuel Weight		763,384
Fuel		252,690
Gross Weight		1,016,074
AMPR Weight		326,306

TABLE E-19

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-353

LGA-144-353		OPERATING WEIGHT	403,384
Delete:			
Ramp Extensions	4,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	430		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,400		
Tiedown Rings	1,210		
Loadmasters	440		
Total	14,910		
LGA-144-353C		OPERATING WEIGHT	388,474
Payload			374,910
ZERO FUEL WEIGHT			763,384
Fuel			252,690
GROSS WEIGHT			1,016,074

REFERENCES

E-1 Defense mapping agency, ADSOINST 8320.1, St. Louis Air Force Station, Missouri, 63118, 1 January 1976.

APPENDIX F. DESCRIPTION OF GROUP IV CONFIGURATIONS

This appendix describes the Group IV configurations, beginning with the new baseline configuration (-400) which was derived from the preferred Group II option, the -223. The foldout page at the back of this volume gives a brief description of the aircraft which are defined in this appendix.

LGA-144-400 BASELINE CONFIGURATION

The -400 baseline is configurationally similar to the -223. The fuselage cross-section radius was increased slightly to allow carriage of 10-foot high containers in the outboard cargo lanes. Additionally, the cargo floor height from the forward ramp aft to the center wingbox rear spar was increased to 14-1/2 feet, which alleviates problems at the ramp crest when loading some large military equipment. This change relocated the flight station relatively higher in the cross section which should improve visibility from the cockpit.

Figure F-1 presents the general arrangement and some pertinent design characteristics of the -400 baseline configuration. Figure F-2 illustrates the ramp and ramp extensions at the forward end of the fuselage. Tables F-1, F-2, and F-3 present more performance and physical characteristics of the -400 baseline. Figure F-3 shows an inboard profile and Figure F-4 presents some details at the forward fuselage; Figure F-5 illustrates the three-stick vehicle loadability. The military payload-range capability at the design point of the -400 is 390,000 pounds for 4000 nm.

LGA-144-411

This point design features a cargo compartment cross section designed solely for a commercial requirement to carry 10-ft high containers. Figure F-6 shows a cross-section comparison of the -400 and -411. Note that the cargo floor height is 11 ft for the -411 compared to 13-1/2 ft for the -400, and the large difference in frontal areas of the two configurations. However, even though it is made up of circular arcs, the flattened cross section fuselage is not nearly as efficient a pressure vessel as a shape approaching circular.

CRUISE MACH NO.	0.78
DESIGN PAYLOAD	390,000 LB
DESIGN RANGE	4,000 N.MI.
OPERATING WT.	394,800 LB
MAX. GROSS WT.	1,038,600 LB
ASPECT RATIO	10.1
WING LOADING	129.4 PSF
THRUST PER ENGINE	58,300 LB

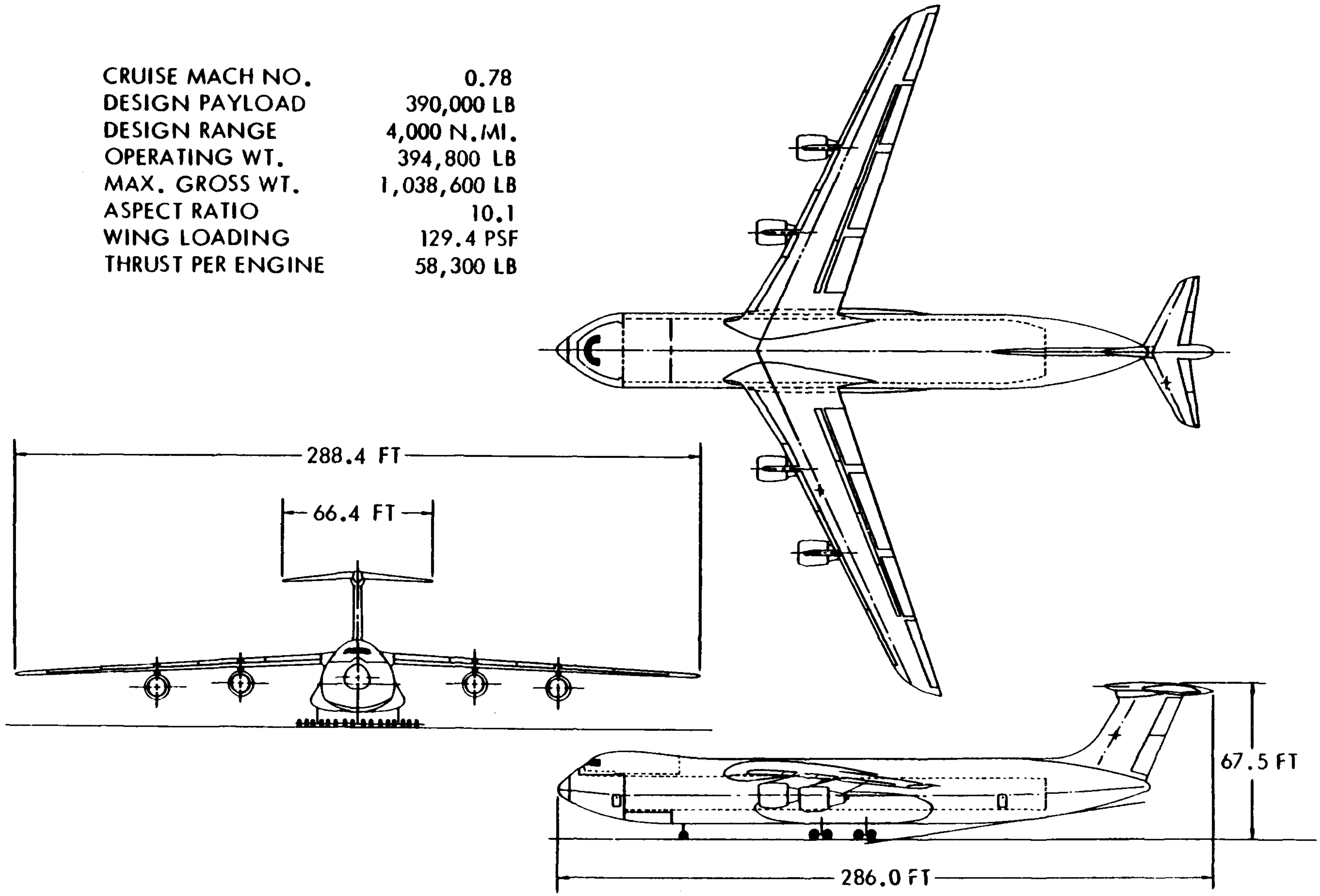


Figure F-1. General Arrangement: LGA-144-400

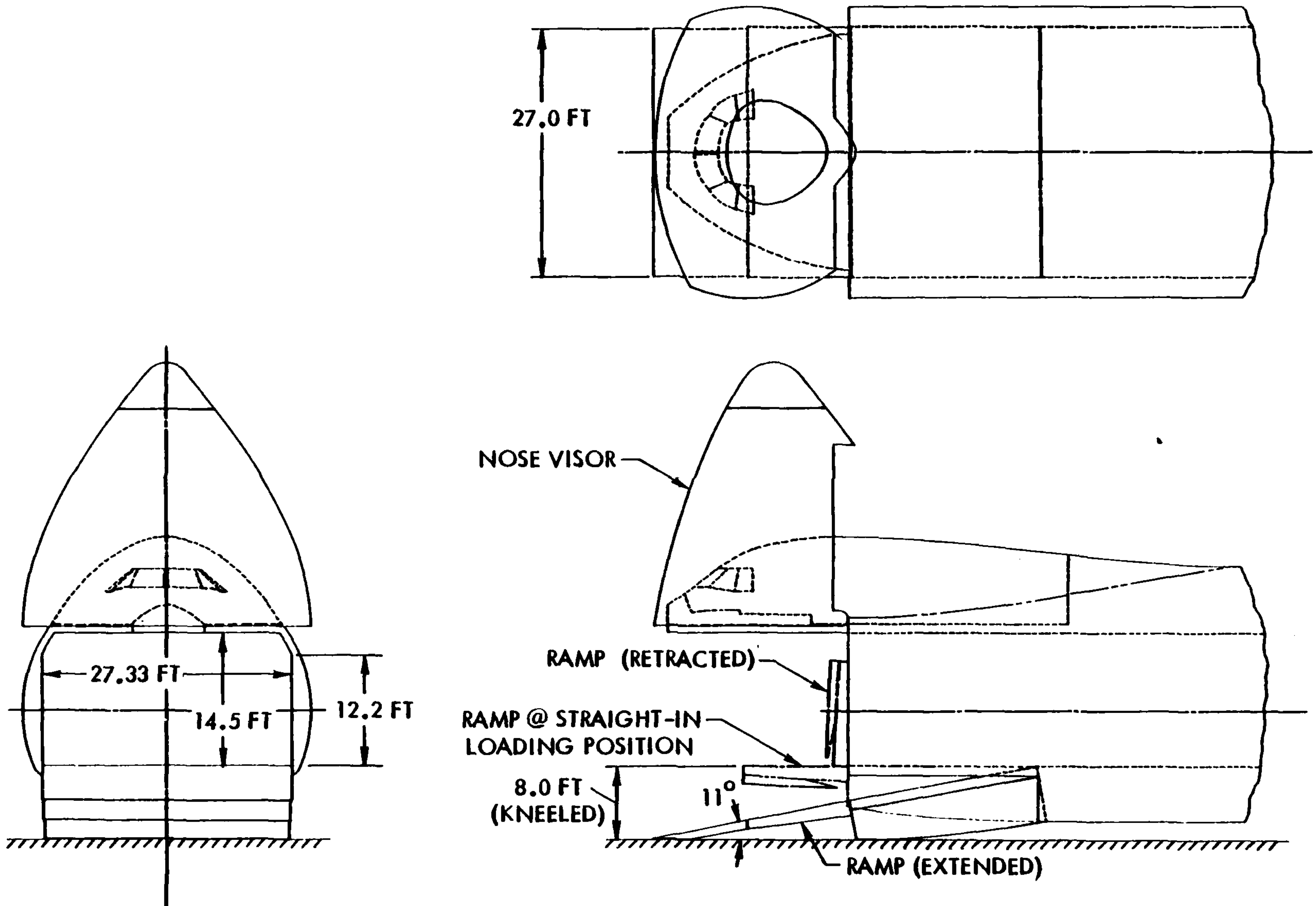


Figure F-2. LGA-144-400 Forward Fuselage

TABLE F-1
DESIGN AND PERFORMANCE DATA LGA-144-400

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,471
Pressure Volume (ft^3)	149,205
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,856	933	1,012
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.10	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	282	65	36
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	58,299
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	390,000	404,250
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,914	10,605
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-2
GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-400

ITEM	POUNDS	
Wing		107,616
Horizontal Tail		5,477
Vertical Tail		4,643
Fuselage		124,180
Landing Gear		42,405
Nose	5,513	
Main	36,892	
Nacelles/Pylons		9,109
Nacelles	3,870	
Pylons	5,239	
Noise Treatment	0	
Propulsion System		53,837
Engines	38,483	
Thrust Reversers	6,465	
Fuel System	5,419	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,963
Auxiliary Power System	1,245	
Surface Controls	8,314	
Instruments	1,600	
Hydraulics and Pneumatics	3,874	
Electrical	4,008	
Avionics	2,400	
Furnishings	7,556	
Air-conditioning and Anti-ice	5,774	
Auxiliary Gear-Equipment	192	
Weight Empty		382,229
Operating Equipment		12,523
Operating Weight		394,752
Payload		390,000
Zero Fuel Weight		784,752
Fuel		253,857
Gross Weight		1,038,609
AMPR Weight		319,614

TABLE F-3
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-400

LGA-144-400		OPERATING WEIGHT	394,752
Delete:			
Ramp Extensions	3,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	280		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,850		
Tiedown Rings	1,250		
Loadmasters	440		
Total	14,250		
LGA-144-400 C		OPERATING WEIGHT	380,502
Payload			404,250
ZERO FUEL WEIGHT			784,752
Fuel			253,857
GROSS WEIGHT			1,038,609

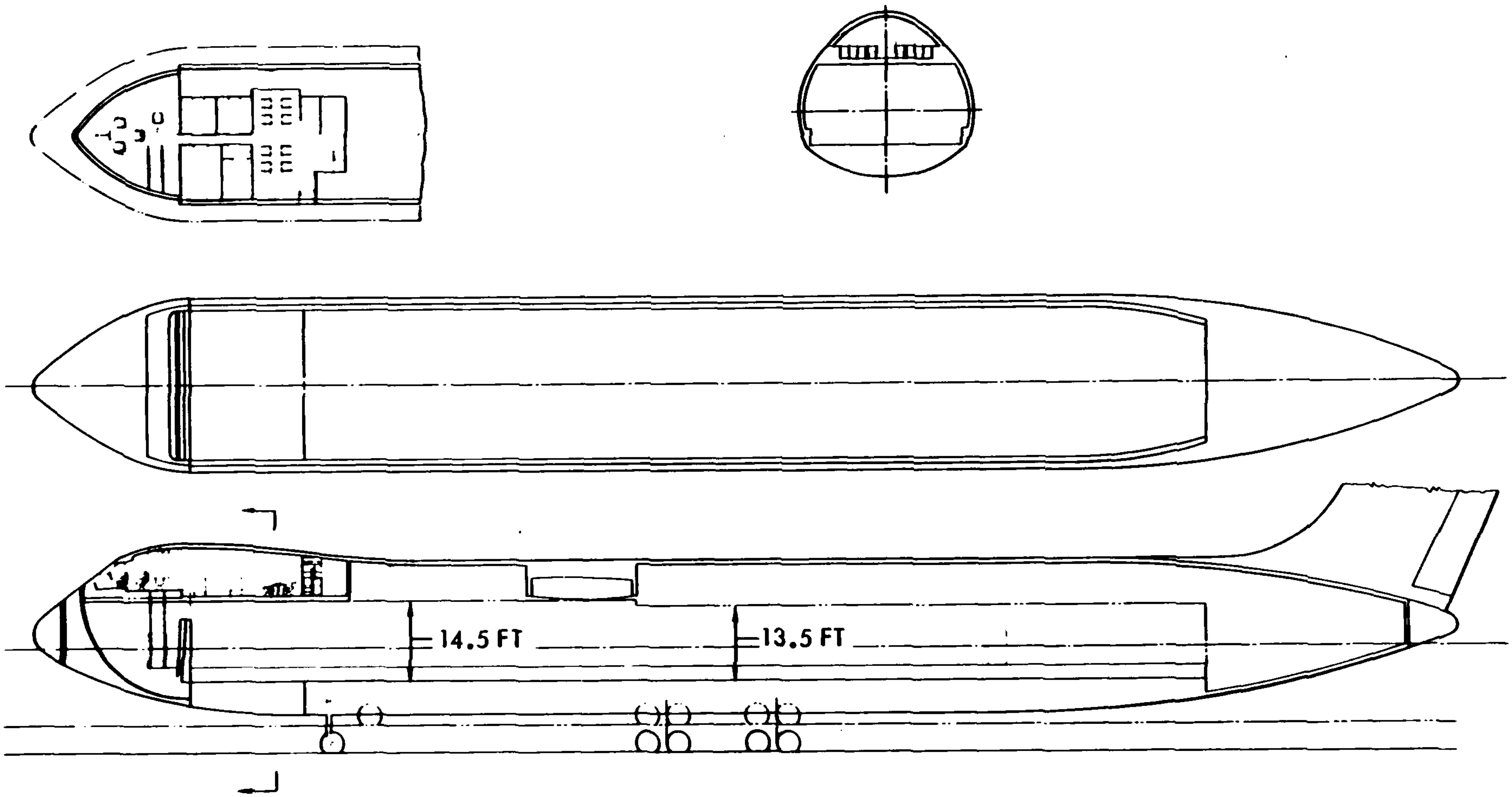


Figure F-3. LGA-144-400 Inboard Profile

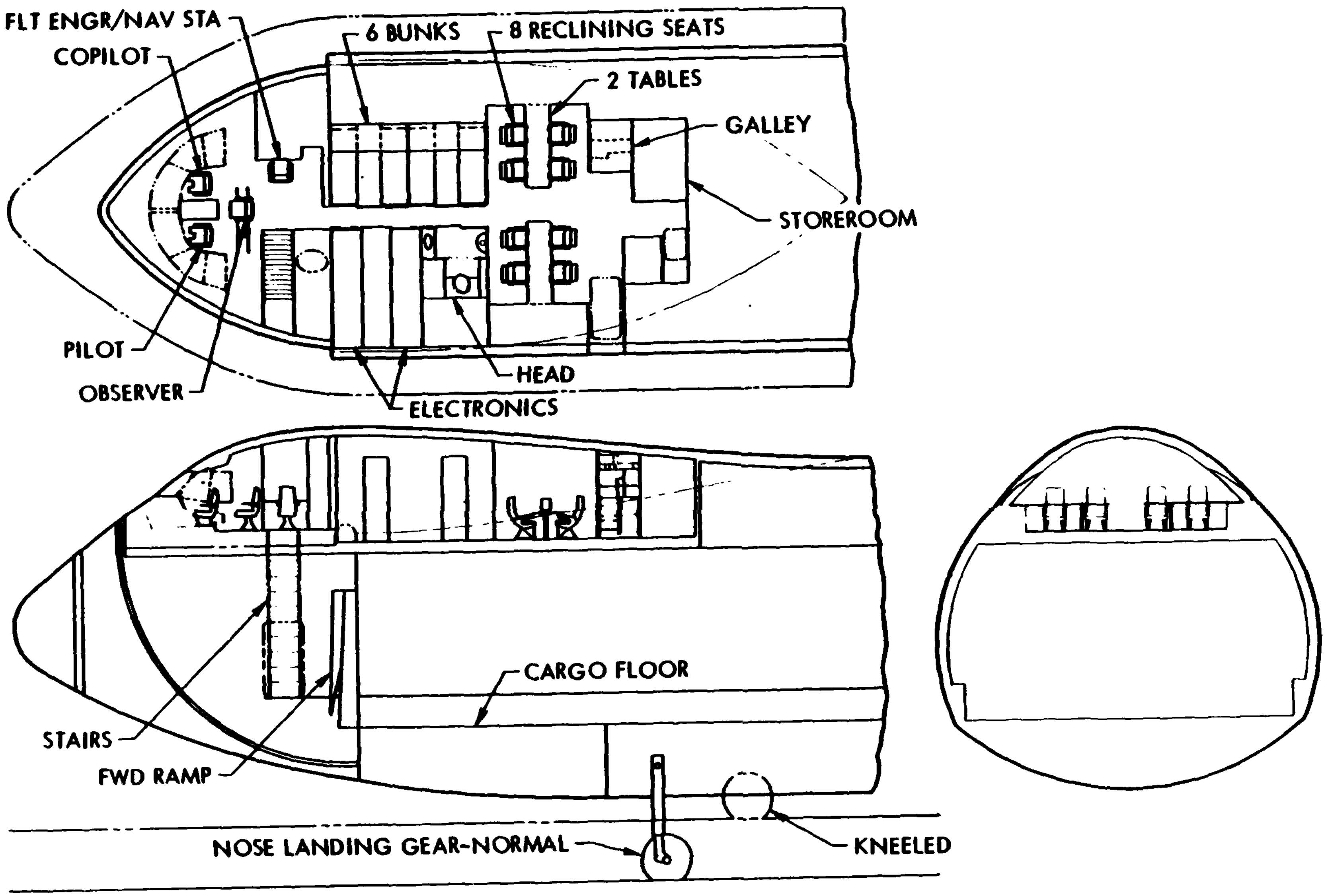


Figure F-4. LGA-144-400 Forward Fuselage Inboard Profile

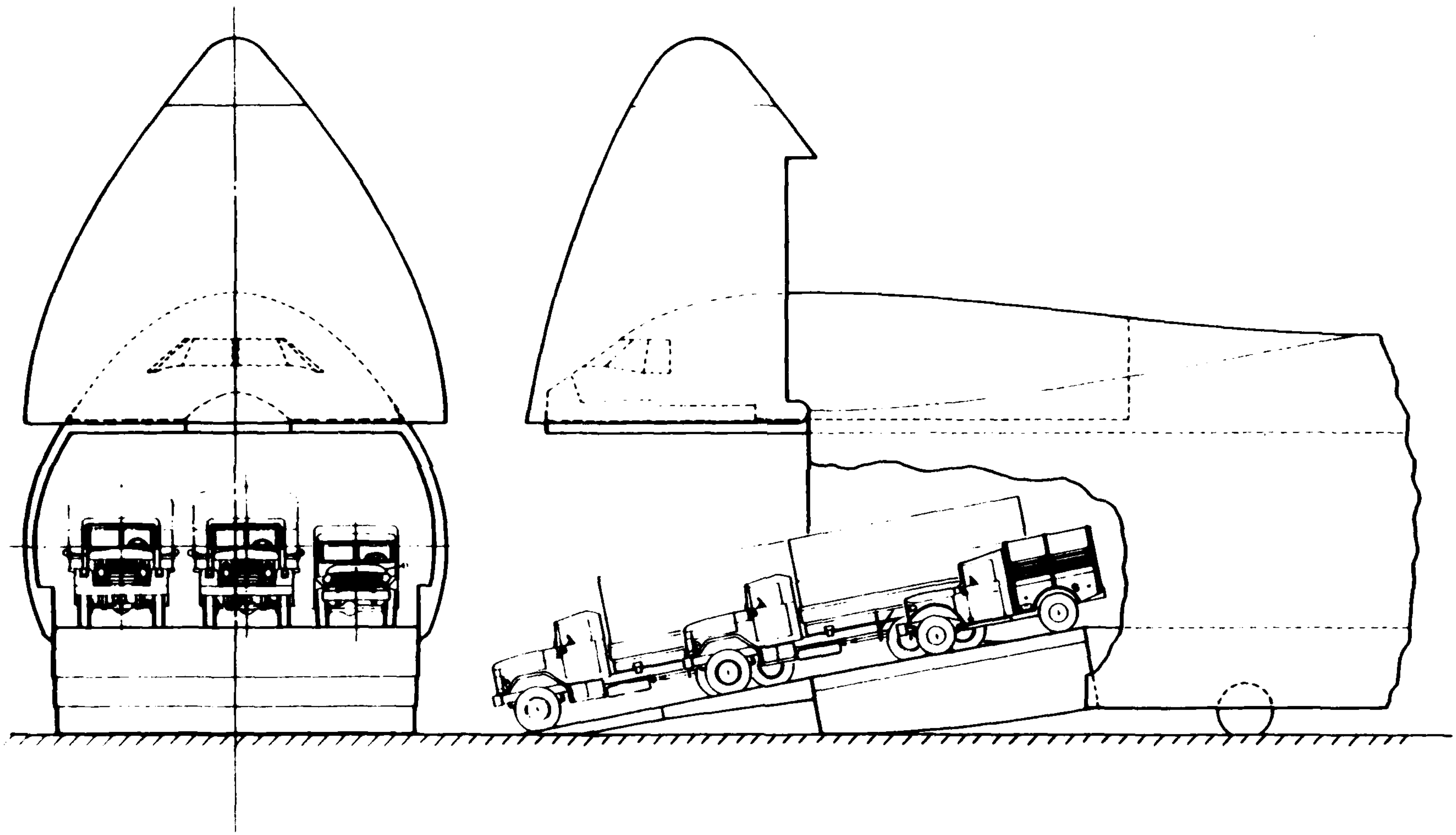


Figure F-5. LGA-144-400 Illustrative Vehicle Loadability

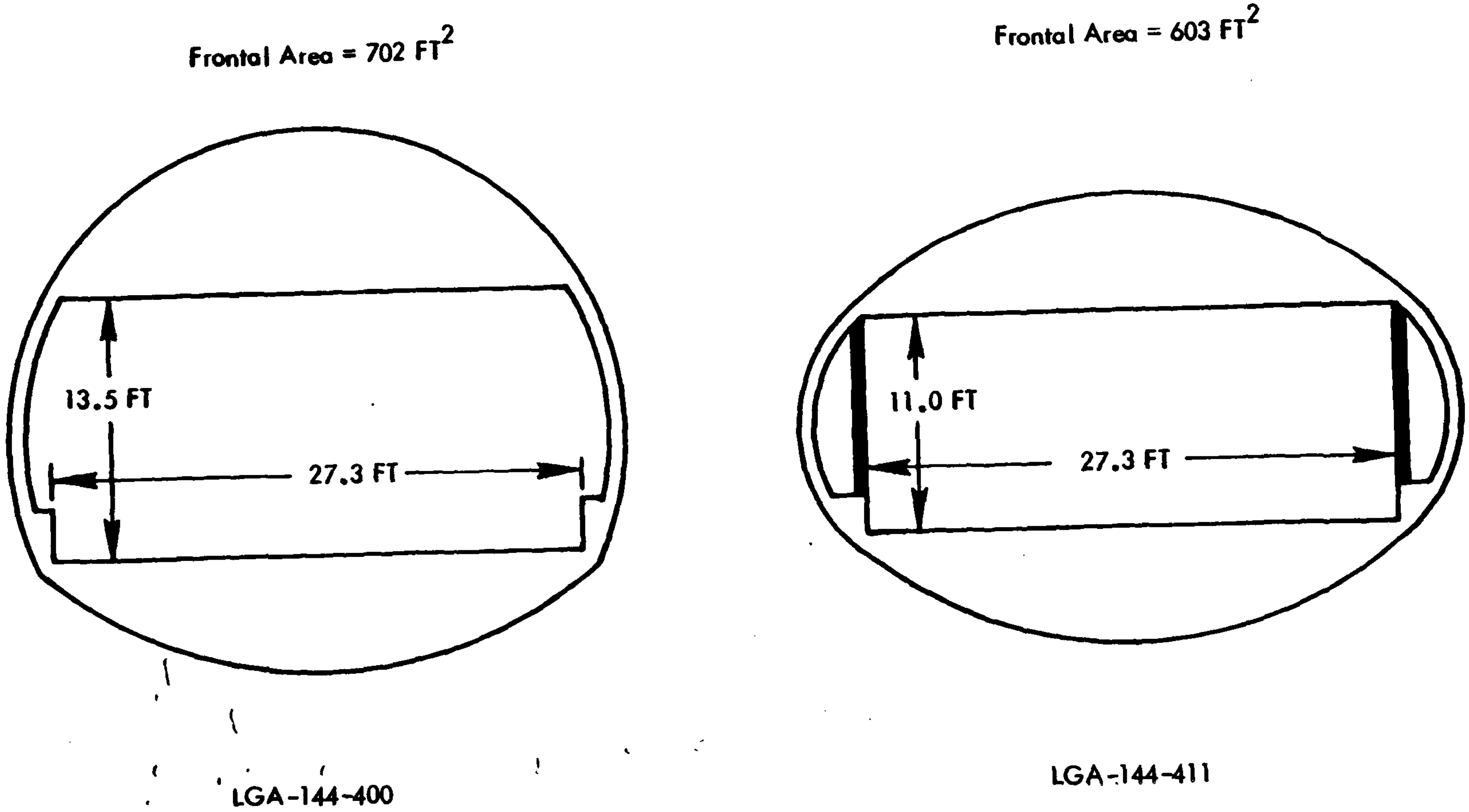


Figure F-6. Cross Section Comparison

The dark vertical lines in the -411 cross section denote tension ties required to react the pressurization loads. From a fuselage weight standpoint, the smaller wetted area is offset by these structural requirements.

The cargo floor planform is identical to the -400 baseline. The aircraft has the same LCG III landing gear and the same military payload-range at the design point as the -400 baseline.

Figure F-7 shows a three-view general arrangement of the -411 with some pertinent design characteristics, and Tables F-4, F-5, and F-6 show additional performance and physical characteristics.

LGA-144-421

This configuration was incorporated in the study to assess the cost-effectiveness of providing integral passenger accommodations in the unoccupied area of the aft upper fuselage behind the wing box. The 13-1/2 ft minimum cargo height in this area is undisturbed, but the area aft of the wing box was provided with a floor designed for 194 passengers in an all-tourist nine abreast seating arrangement at a 34 in pitch. (See Figure F-8.) Approximately 9500 lb is added to the fuselage weight for door and window cutouts and the floor, and 19,200 lb is added for passenger accommodations including toilets and galleys. In all other aspects the -421 closely resembles the -400 baseline configuration.

The 4000 nm range remains the same as the -400; however, the payload of the -421 has been increased to approximately 428,000 lb at the design point for the additional weight of the passengers and their baggage.

Tables F-7, F-8, and F-9 present performance and physical characteristics of the -421. All passenger configurations have additional doors provided to allow egress of passengers in the event of an emergency. Time did not permit an investigation of water ditching attitudes, but the height of the passenger doors above the probable water line is considerable and should not represent a problem. Seats are shown facing forward, in accordance with commercial practice, although there is an Air Force requirement to have transport seats face aft.

CRUISE MACH NO.	0.78
DESIGN PAYLOAD	390,000 LB
DESIGN RANGE	4,000 NM
OPERATING WT	395,000 LB
MAX GROSS WT	1,041,000 LB
ASPECT RATIO	10.1
WING LOADING	129.4 PSF
THRUST PER ENGINE	58,700 LB

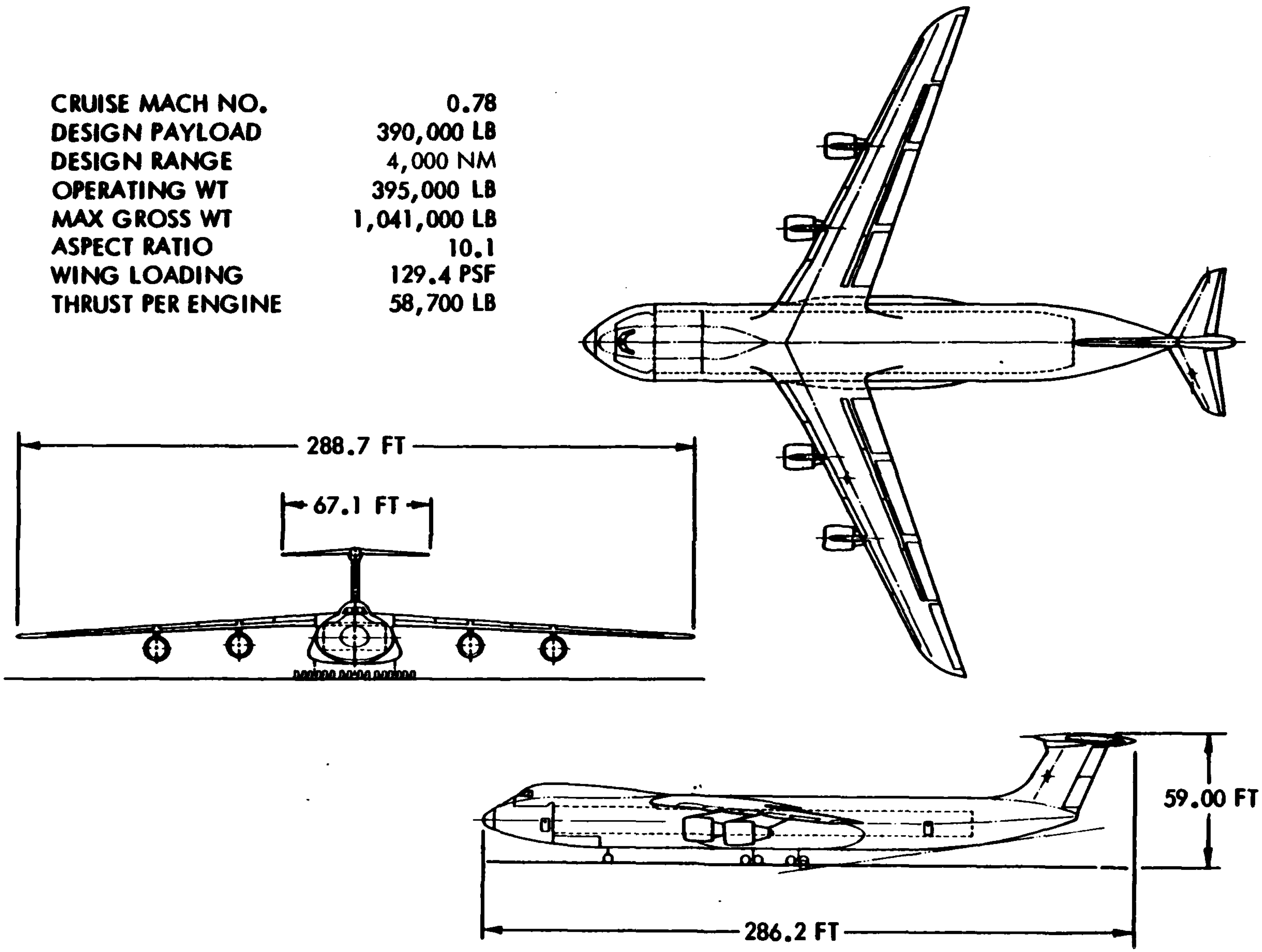


Figure F-7. LGA-144-411 General Arrangement

TABLE F-4
DESIGN AND PERFORMANCE DATA LGA-144-411

FUSELAGE GEOMETRY

Length (ft)	261
Wetted Area (ft^2)	20,904
Pressure Volume (ft^3)	133,577
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 11.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,873	955	877
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.10	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	282	66	33
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	58,659
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	390,000	404,250
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,939	10,609
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-5

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-411

ITEM	POUNDS	
Wing		107,807
Horizontal Tail		5,569
Vertical Tail		4,202
Fuselage		124,392
Landing Gear		42,432
Nose	5,516	
Main	36,916	
Nacelles/Pylons		9,162
Nacelles	3,889	
Pylons	5,273	
Noise Treatment	0	
Propulsion System		54,220
Engines	38,753	
Thrust Reversers	6,511	
Fuel System	5,487	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		34,777
Auxiliary Power System	1,247	
Surface Controls	8,341	
Instruments	1,604	
Hydraulics and Pneumatics	3,887	
Electrical	4,020	
Avionics	2,400	
Furnishings	7,501	
Air-conditioning and Anti-ice	5,585	
Auxiliary Gear-Equipment	193	
Weight Empty		382,561
Operating Equipment		12,515
Operating Weight		395,077
Payload		390,000
Zero Fuel Weight		785,077
Fuel		255,918
Gross Weight		1,040,994
AMPR Weight		319,658

TABLE F-6

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-411

LGA-144-411		OPERATING WEIGHT	395,077
Delete:			
Ramp Extensions	3,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	280		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,850		
Tiedown Rings	1,250		
Loadmasters	440		
Total	14,250		
LGA-144-411C		OPERATING WEIGHT	380,827
Payload			404,250
ZERO FUEL WEIGHT			785,077
Fuel			255,917
GROSS WEIGHT			1,040,994

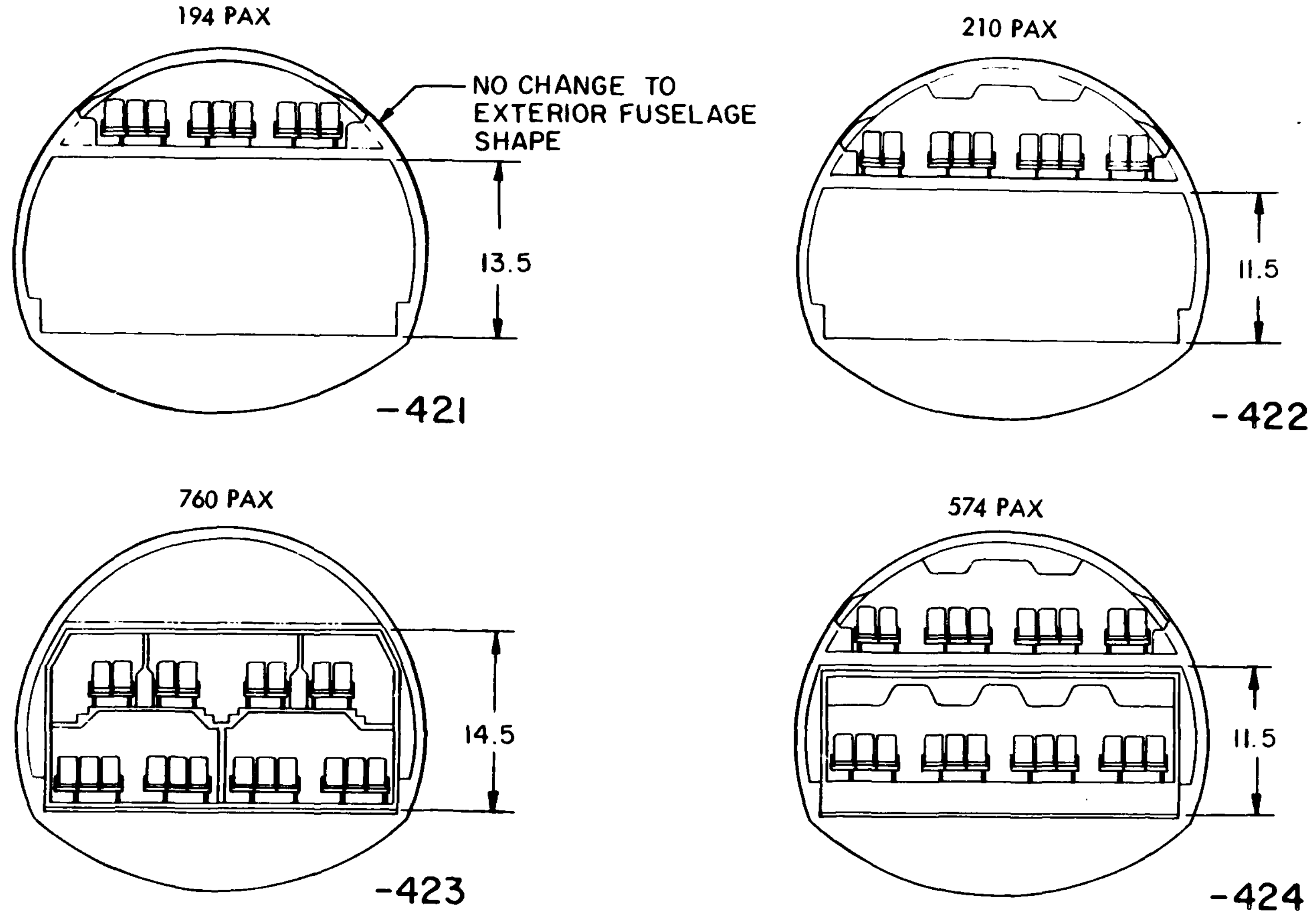


Figure F-8. Combi Configurations

TABLE F-7
DESIGN AND PERFORMANCE DATA LGA-144-421

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,471
Pressure Volume (ft^3)	149,205
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	8,628	1,058	1,077
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.10	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	298	72	40
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	65,088
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	427,925	442,175
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	8,002	10,633
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-8
GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-421

ITEM	POUNDS	
Wing		124,269
Horizontal Tail		6,610
Vertical Tail		5,612
Fuselage		133,035
Landing Gear		44,684
Nose	5,809	
Main	38,875	
Nacelles/Pylons		10,121
Nacelles	4,228	
Pylons	5,892	
Noise Treatment	0	
Propulsion System		60,137
Engines	43,608	
Thrust Reversers	7,326	
Fuel System	5,733	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		55,782
Auxiliary Power System	1,357	
Surface Controls	9,228	
Instruments	1,625	
Hydraulics and Pneumatics	4,300	
Electrical	4,092	
Avionics	2,400	
Furnishings	26,762	
Air-conditioning and Anti-ice	5,802	
Auxiliary Gear-Equipment	215	
Weight Empty		440,249
Operating Equipment		14,088
Operating Weight		454,337
Payload		427,925
Zero Fuel Weight		882,262
Fuel		281,293
Gross Weight		1,163,555
AMPR Weight		371,313

TABLE F-9
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-421

LGA-144-421	OPERATING WEIGHT	454,337
Delete:		
Ramp Extensions	3,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	280	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,850	
Tiedown Rings	1,250	
Loadmasters	440	
Total	14,250	
LGA-144-421C	OPERATING WEIGHT	440,087
Payload		442,175
ZERO FUEL WEIGHT		882,262
Fuel		281,293
GROSS WEIGHT		1,163,555

Galleys and heads comparable to L-1011 configurations are provided to accommodate the number of passengers for all the passenger options. The -421 and -422 will use a main deck container to carry baggage, while the -423 and -424 will carry baggage on the unoccupied ramp area.

LGA-144-422

Unlike the -421, which does not interfere with the cargo compartment height, the -422 has a passenger floor that decreases the cargo compartment height to 11-1/2 ft. The additional width allows a 10-abreast seat arrangement, and seat pitch is increased to 36 in., resulting in a 210-passenger capacity.

Figure F-9 shows a three-view general arrangement of the -422 aircraft with pertinent performance and physical characteristics, and Tables F-10, F-11, and F-12 expand on this data. Complete plan and side-views show the entire passenger arrangement with heads and galley in Figure F-10. Sections in Figure F-11 show typical loading arrangements forward and aft of the rear wing spar. Approximately 11,000 pounds are added to the fuselage weight for cutouts and 20,700 pounds for passenger furnishings. Design payload is again increased for the weight of the passengers and their baggage, to 431,000 lb.

LGA-144-423

This option is incorporated to assess the cost-effectiveness of a configuration which can serve as an all-cargo aircraft, or as an all-passenger aircraft by adding modules in the cargo compartment.

The cargo compartment height has been increased to 14-1/2 ft throughout to provide room for the double deck modules. Cut outs for escape hatches and doors brought about an increase of approximately 2000 lb to the fuselage weight, and passenger furnishings added an additional 38,700 lb for the 760 passengers that can be carried in the -423.

Figure F-8 shows a cross section through the aircraft and the module and Figure F-12 shows an isometric of the moduler arrangement itself. Note that doors are provided to allow movement in a fore-aft direction throughout the

CRUISE MACH NO.	0.78
DESIGN PAYLOAD	431,000 LB
DESIGN RANGE	4,000 NM
OPERATING WT	460,700 LB
MAX GROSS WT	1,175,200 LB
ASPECT RATIO	10.1
WING LOADING	129.4 PSF
THRUST PER ENGINE	65,700 LB

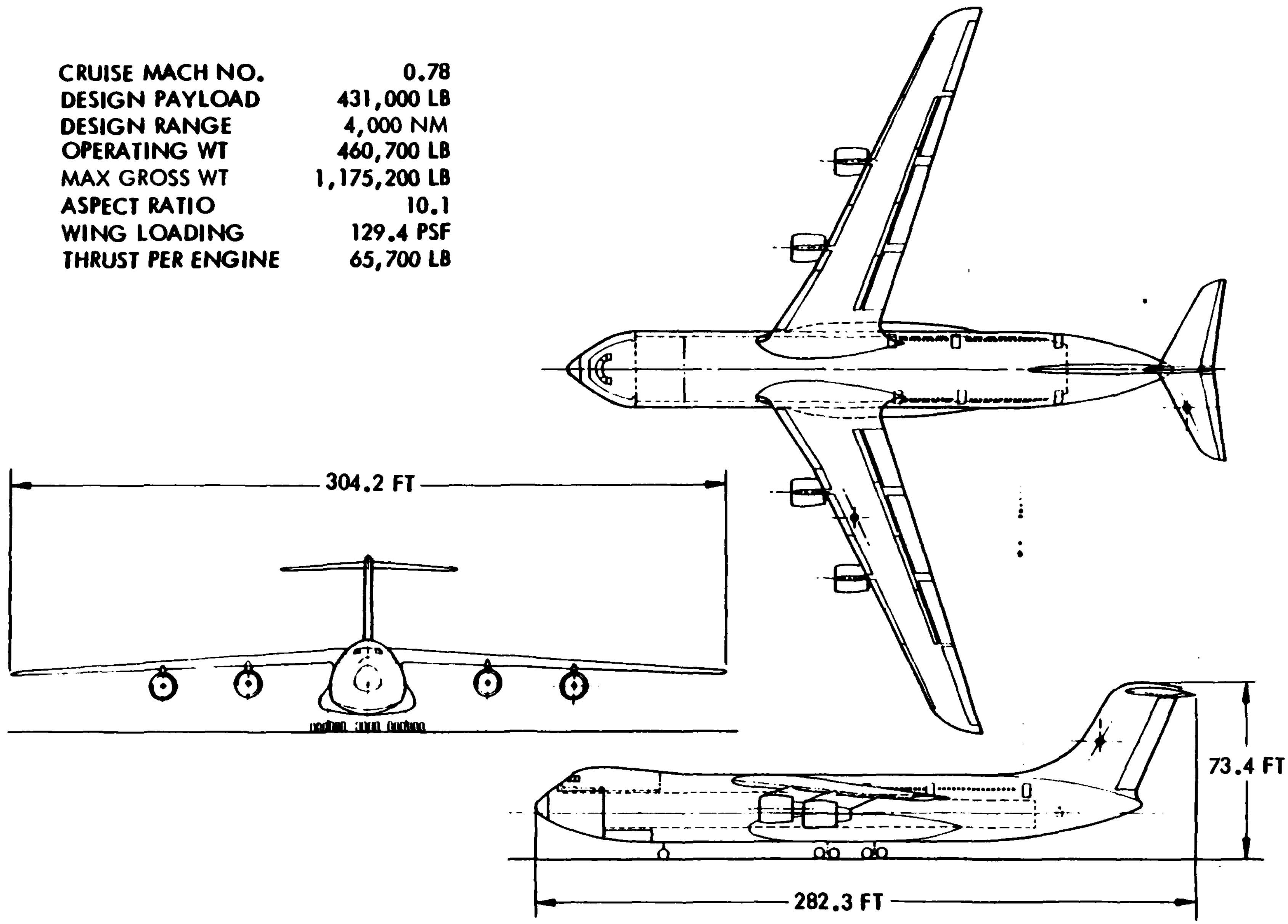


Figure F-9. LGA-144-422 General Arrangement

TABLE F-10
DESIGN AND PERFORMANCE DATA LGA-144-422

FUSELAGE GEOMETRY

Length (ft)	259
Wetted Area (ft^2)	21,471
Pressure Volume (ft^3)	149,205
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY

	WING	HORIZ	VERT
Area (ft^2) (Basic)	8,892	1,187	1,319
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.14	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	300	73	41
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	65,668
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE

	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	431,000	445,250
Range (nm)	4,000	3,525
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	8,004	10,636
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-11

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-422

ITEM	POUNDS	
Wing		126,277
Horizontal Tail		6,729
Vertical Tail		3,733
Fuselage		134,489
Landing Gear		44,900
Nose	5,837	
Main	39,063	
Nacelles/Pylons		10,207
Nacelles	4,259	
Pylons	5,948	
Noise Treatment	0	
Propulsion System		60,675
Engines	44,049	
Thrust Reversers	7,400	
Fuel System	5,756	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		57,439
Auxiliary Power System	1,368	
Surface Controls	9,315	
Instruments	1,628	
Hydraulics and Pneumatics	4,341	
Electrical	4,103	
Avionics	2,400	
Furnishings	28,262	
Air-conditioning and Anti-ice	5,805	
Auxiliary Gear-Equipment	217	
Weight Empty		446,448
Operating Equipment		14,219
Operating Weight		460,667
Payload		431,000
Zero Fuel Weight		891,667
Fuel		283,567
Gross Weight		1,175,235
AMPR Weight		376,957

TABLE F-12
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-422

LGA-144-422		OPERATING WEIGHT	460,667
Delete:			
Ramp Extensions	3,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	280		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,850		
Tiedown Rings	1,250		
Loadmasters	440		
Total	14,250		
LGA-144-422C		OPERATING WEIGHT	446,417
Payload			445,250
ZERO FUEL WEIGHT			891,667
Fuel			283,568
GROSS WEIGHT			1,175,235

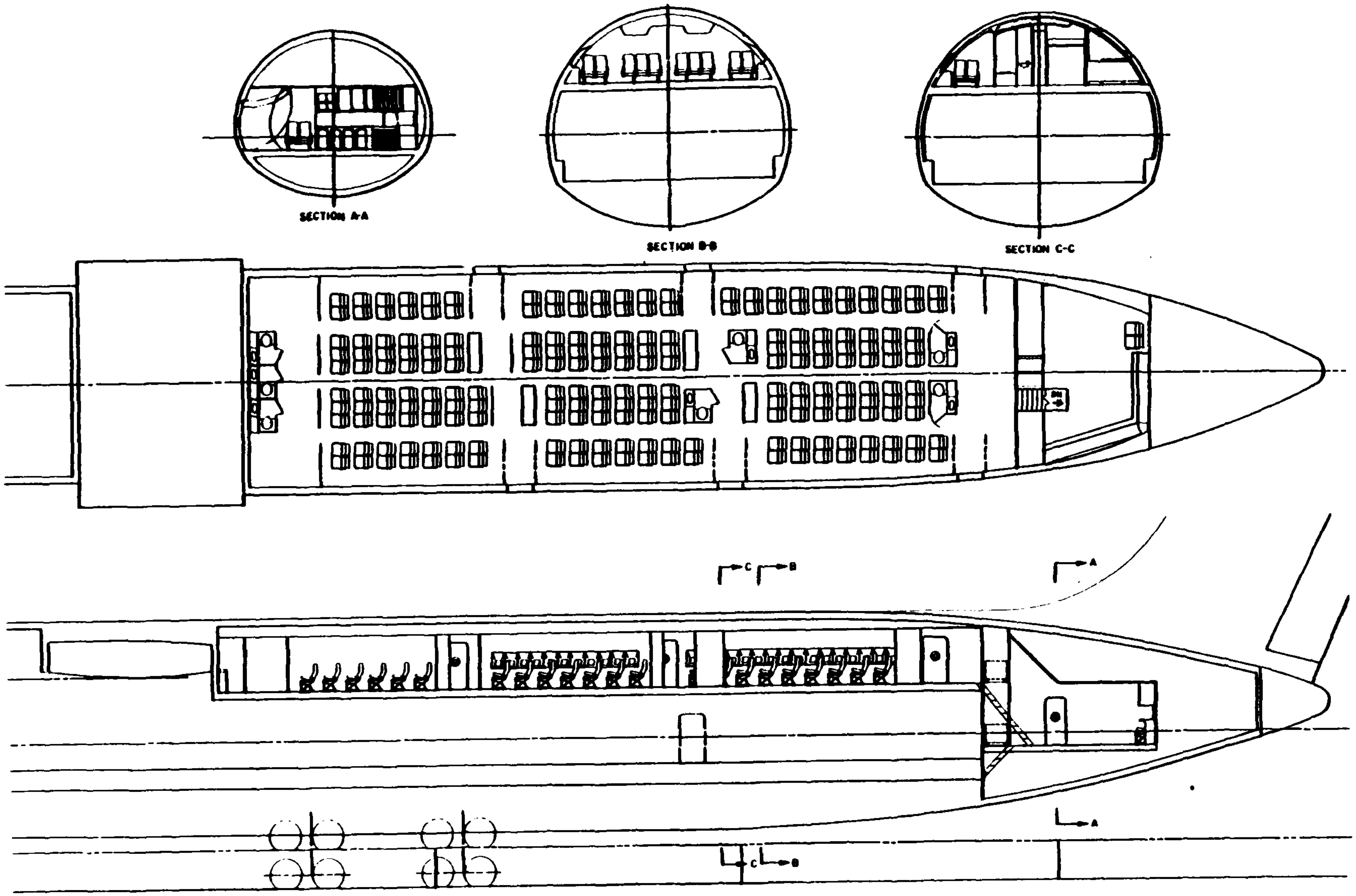


Figure F-10. LGA-144-422 Inboard Profile

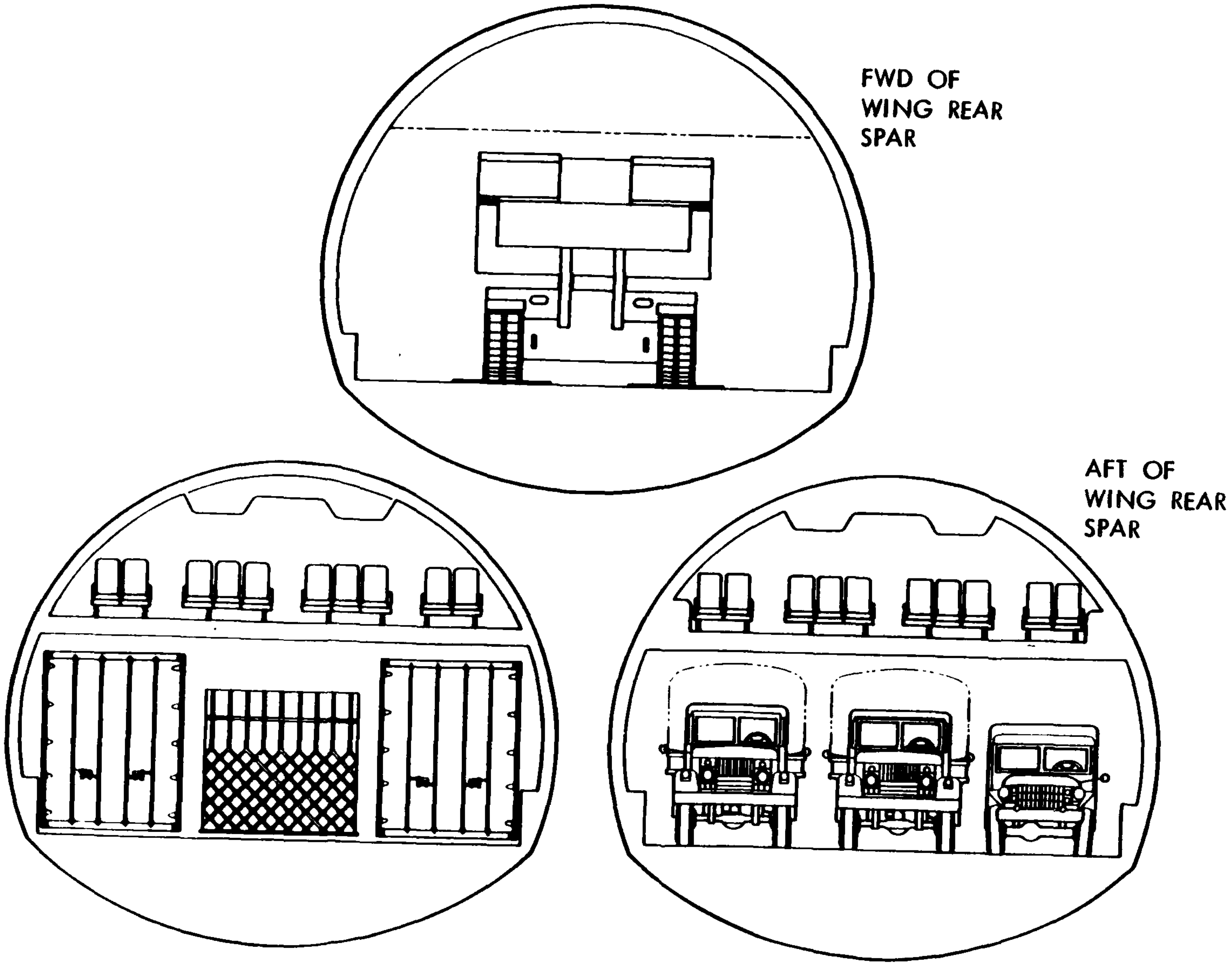


Figure F-11. Typical Loads for Combi Aircraft - LGA-144-422

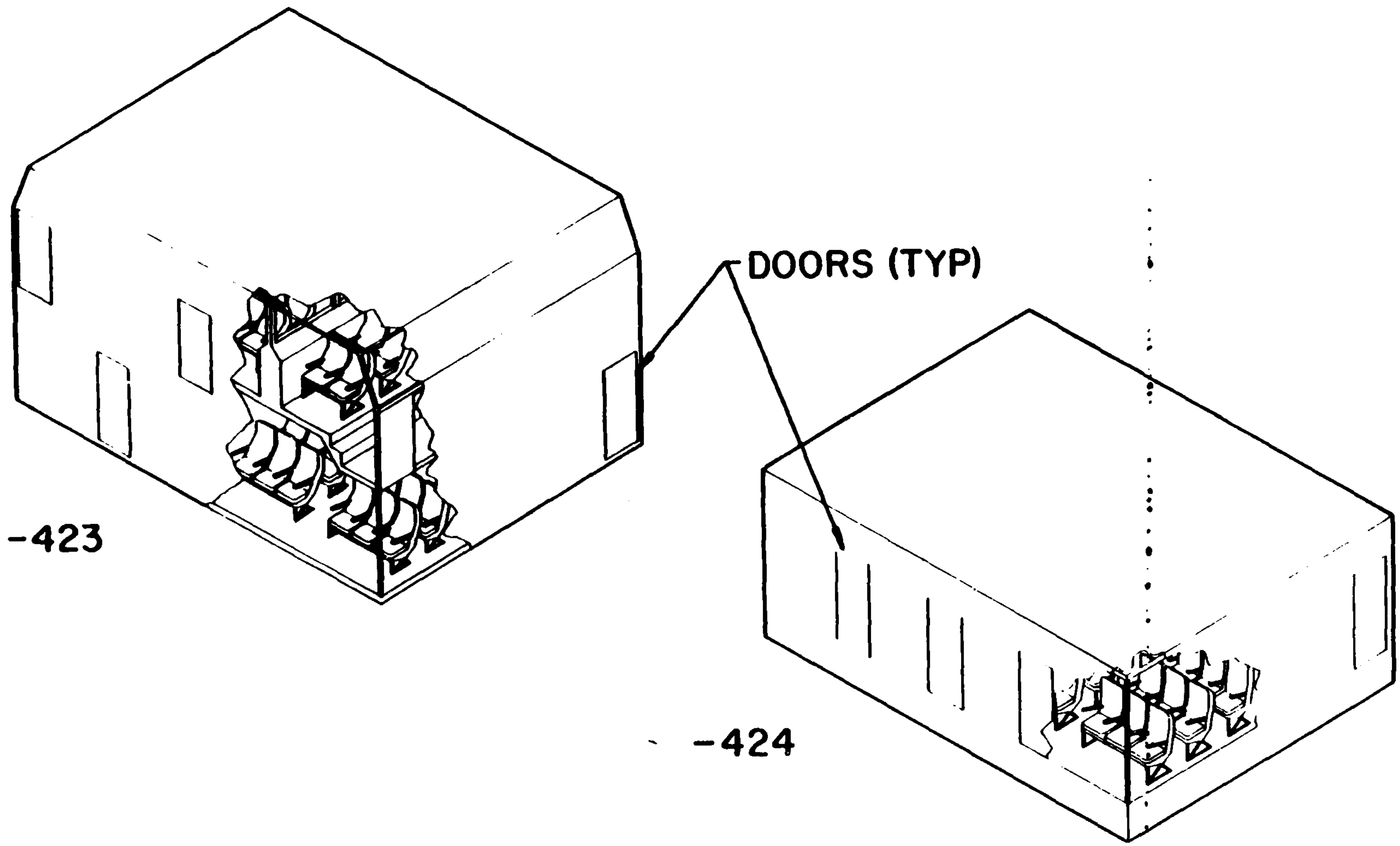


Figure F-12. Module Configuration

aircraft. Also, doors are provided in the modules to allow emergency aircraft exiting. These doors are matched with doors in the fuselage skin. Special Galley and head modules are also provided. This configuration lends itself to combine cargo-passenger loads, although none were investigated for this report.

Tables F-13, F-14, and F-15 present performance and physical characteristics of the -423 configuration.

LGA-144-424

This option combines the integral passenger provisions of the -422 with the capability to carry passenger modules, providing a configuration which can serve as a cargo/passenger transport or as an all-passenger configuration. As a cargo/passenger configuration, 210 integral seats are provided aft of the wing box as with the -422, and cargo is carried on the main cargo floor. As an all-passenger configuration, single deck modules are installed on the main cargo floor which accommodate 364 passengers plus 210 integral seats located in the compartment behind the wing box; hence, a total 574 passengers can be accommodated. The section shown in Figure F-8 depicts the seating arrangement, and Figure F-12 provides an isometric view of the seating module. The fuselage weight penalty for floors and cutouts is approximately 12,000 lb, and 38,900 lb are added for passenger accommodations.

As with the -422, the cargo clearance height is 11-1/2 ft aft of the wing box and 14-1/2 ft forward; hence, accommodations for outsized cargo are retained in the forward fuselage section. Tables F-16, F-17, and F-18 present performance and physical characteristics of the -424.

LGA-144-431 AND LGA-144-432

These two design options were included to assess the cost-effectiveness of configurations designed to carry greater payloads for shorter distances than the -400 baseline. The -431 has a payload-range design point of 416,000 pounds at 3500 nm while the design point for the -432 is 471,400 lb at 2500 nm. (See Figure F-13.) Hence, the zero fuel weight for the -431 is designed for an additional 26,000 lb and 81,400 lb for the -432 over the -400 baseline.

TABLE F-13
DESIGN AND PERFORMANCE DATA LGA-144-423

FUSELAGE GEOMETRY			
Length (ft)	259		
Wetted Area (ft^2)	21,471		
Pressure Volume (ft^3)	149,205		
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0		
Forward Aperture Width (ft)	27.3		
Aft Aperture Width (ft)	None		
SURFACE GEOMETRY	**WING**	**HORIZ**	**VERT**
Area (ft^2) (Basic)	8,435	1,052	1,154
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.10	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	291	69	38
Wing Loading (lb/ft^2)	129.35	-	-
ENGINE			
Thrust (Sea Level Static - lb)	62,444		
TSFC (Cruise lb/lb/hr)	0.594		

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	390,000	404,250
Range (nm)	4,000	3,520
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,983	10.614
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-14

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-423

ITEM	POUNDS	
Wing		117,748
Horizontal Tail		6,083
Vertical Tail		5,165
Fuselage		126,536
Landing Gear		43,798
Nose	5,694	
Main	38,105	
Nacelles/Pylons		9,727
Nacelles	4,089	
Pylons	5,637	
Noise Treatment	0	
Propulsion System		57,673
Engines	41,603	
Thrust Reversers	5,611	
Fuel System	6,989	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		74,638
Auxiliary Power System	1,313	
Surface Controls	8,861	
Instruments	1,615	
Hydraulics and Pneumatics	4,129	
Electrical	4,060	
Avionics	2,400	
Furnishings	46,262	
Air-conditioning and Anti-ice	5,791	
Auxiliary Gear-Equipment	206	
Weight Empty		441,368
Operating Equipment		13,124
Operating Weight		454,492
Payload		390,000
Zero Fuel Weight		844,492
Fuel		270,394
Gross Weight		1,114,886
AMPR Weight		374,901

TABLE F-15

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-423

LGA-144-423	OPERATING WEIGHT	454,492
Delete:		
Ramp Extensions	3,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	280	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,850	
Tiedown Rings	1,250	
Loadmasters	440	
Total	14,250	
LGA-144-423C	OPERATING WEIGHT	440,242
Payload		404,250
ZERO FUEL WEIGHT		844,492
Fuel		270,394
GROSS WEIGHT		1,114,886

TABLE F-16

DESIGN AND PERFORMANCE DATA LGA-144-424

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,471
Pressure Volume (ft^3)	149,205
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	9,165	1,242	1,374
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.10	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	304	75	41
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	67,762
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	431,000	445,250
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	
Critical field length/ FAA field length (ft)	8,000	10,614
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

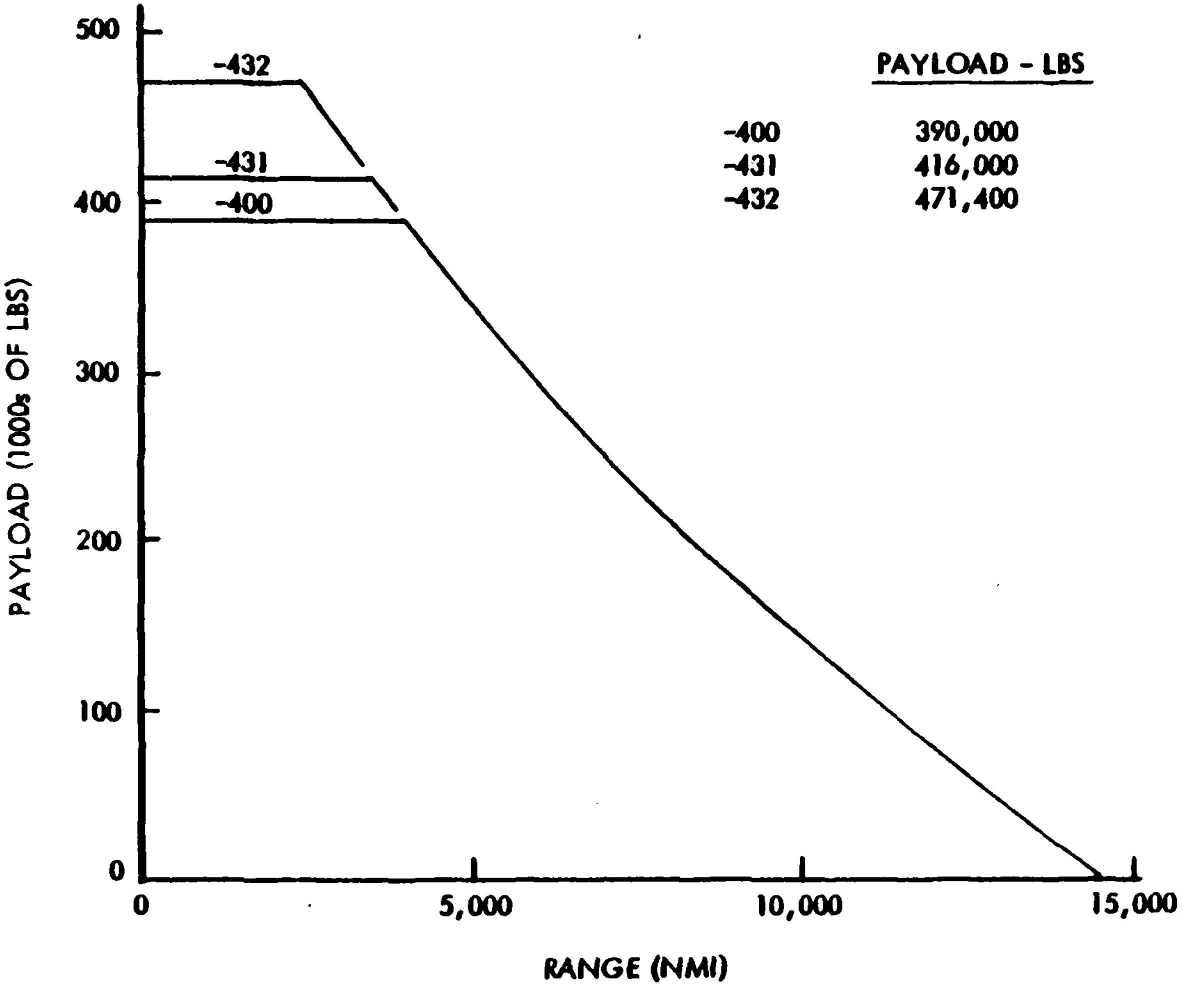
TABLE F-17

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-424

ITEM	POUNDS	
Wing		130,758
Horizontal Tail		7,006
Vertical Tail		5,932
Fuselage		135,581
Landing Gear		45,556
Nose	5,922	
Main	39,633	
Nacelles/Pylons		10,519
Nacelles	4,368	
Pylons	6,151	
Noise Treatment	0	
Propulsion System		62,634
Engines	45,647	
Thrust Reversers	7,669	
Fuel System	5,848	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		76,085
Auxiliary Power System	1,400	
Surface Controls	9,570	
Instruments	1,633	
Hydraulics and Pneumatics	4,460	
Electrical	4,123	
Avionics	2,400	
Furnishings	46,462	
Air-conditioning and Anti-ice	5,812	
Auxiliary Gear-Equipment	224	
Weight Empty		474,069
Operating Equipment		14,529
Operating Weight		488,599
Payload		431,000
Zero Fuel Weight		919,599
Fuel		291,666
Gross Weight		1,211,265
AMPR Weight		402,637

TABLE F-18
SUMMARY OF WEIGHT CHANGES TO GET
COMMERCIAL CONFIGURATION LGA-144-424

LGA-144-424		OPERATING WEIGHT	488,599
Delete:			
Ramp Extensions	3,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	280		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,850		
Tiedown Rings	1,250		
Loadmasters	440		
Total	14,250		
LGA-144-424C		OPERATING WEIGHT	474,349
Payload			445,250
ZERO FUEL WEIGHT			919,599
Fuel			291,666
GROSS WEIGHT			1,211,265



"X" POINT

	PAYLOAD - LBS	RANGE - NMI
-400	390,000	4000
-431	416,000	3500
-432	471,400	2500

Figure F-13. Payload-Range Curves for Maximum Structural Payload Design Feature

The external configuration of these two options is very similar to the -400 baseline varying only because of the above mentioned weight changes. The cargo floor planform is identical to the -400 although the increased payload results in heavier structure. The flight station, fore and aft fuselage and landing gear rolling stock are the same as the -400 baseline.

Tables F-19, F-20, and F-21 present performance and physical characteristics of the -431, and Tables F-22, F-23 and, F-24 present the same for the -432.

LGA-144-441

This option is included in the study to assess the cost implication of a configuration designed to a 60,000-hour commercial operational profile as defined in the following mission profile:

FLIGHT TIME (HRS)	PAYLOAD % MAXIMUM	ALTITUDE	FREQUENCY %
6.0	75	High	20
8.0	50	High	20
8.0	75	High	20
8.0	100	High	20
3.0	75	High	20

The above spectrum results in designing to a stress level of 38,000 psi. Thus, if the option were operated to the following military mission profile it would have a service life of about 62,300 hours:

FLIGHT TIME (HRS)	PAYLOAD % MAXIMUM	ALTITUDE	FREQUENCY %
3.0	Zero	1000 ft	25
8.0	50	High	50
9.0	100 (2.25g max)	High	25

TABLE F-19

DESIGN AND PERFORMANCE DATA LGA-144-431

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,471
Pressure Volume (ft^3)	149,205
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,902	946	1,015
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.10	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	281	65	36
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	58,778
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	416,000	430,250
Range (nm)	3,500	3,050
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,914	10,603
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-20

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-431

ITEM	POUNDS	
Wing		110,010
Horizontal Tail		5,541
Vertical Tail		4,662
Fuselage		124,371
Landing Gear		42,777
Nose	5,561	
Main	37,216	
Nacelles/Pylons		9,180
Nacelles	3,895	
Pylons	5,285	
Noise Treatment	0	
Propulsion System		54,286
Engines	38,842	
Thrust Reversers	6,526	
Fuel System	5,448	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		35,036
Auxiliary Power System	1,250	
Surface Controls	8,360	
Instruments	1,599	
Hydraulics and Pneumatics	3,896	
Electrical	4,005	
Avionics	2,400	
Furnishings	7,556	
Air-conditioning and Anti-ice	5,775	
Auxiliary Gear-Equipment	193	
Weight Empty		385,862
Operating Equipment		12,983
Operating Weight		398,845
Payload		390,000
Zero Fuel Weight		788,845
Fuel		255,979
Gross Weight		1,044,824
AMPR Weight		322,703

TABLE F-21
SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-431

LGA-144-431	OPERATING WEIGHT	398,845
Delete:		
Ramp Extensions	3,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	280	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,850	
Tiedown Rings	1,250	
Loadmasters	440	
Total	14,250	
LGA-144-431C	OPERATING WEIGHT	384,595
Payload		430,250
ZERO FUEL WEIGHT		814,845
Fuel		229,979
GROSS WEIGHT		1,044,824

TABLE F-22

DESIGN AND PERFORMANCE DATA LGA-144-432

FUSELAGE GEOMETRY

Length (ft)	259
Wetted Area (ft^2)	21,471
Pressure Volume (ft^3)	149,205
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	8,001	967	1,032
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.8	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	2.94	65	37
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	59,549
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	471,400	485,650
Range (nm)	2,500	2,100
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,918	10,609
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-23

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-432

ITEM	POUNDS	
Wing		116,413
Horizontal Tail		5,646
Vertical Tail		4,724
Fuselage		124,782
Landing Gear		43,577
Nose	5,665	
Main	37,912	
Nacelles/Pylons		9,295
Nacelles	3,936	
Pylons	5,359	
Noise Treatment	0	
Propulsion System		55,003
Engines	39,421	
Thrust Reversers	6,623	
Fuel System	5,490	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		35,196
Auxiliary Power System	1,262	
Surface Controls	8,454	
Instruments	1,601	
Hydraulics and Pneumatics	3,940	
Electrical	4,010	
Avionics	2,400	
Furnishings	7,556	
Air-conditioning and Anti-ice	5,778	
Auxiliary Gear-Equipment	196	
Weight Empty		394,637
Operating Equipment		13,929
Operating Weight		408,565
Payload		390,000
Zero Fuel Weight		798,565
Fuel		259,249
Gross Weight		1,057,814
AMPR Weight		330,500

TABLE F-24

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-432

LGA-144-432	OPERATING WEIGHT	408,565
Delete:		
Ramp Extensions	3,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	280	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,850	
Tiedown Rings	1,250	
Loadmasters	440	
Total	14,250	
LGA-144-432C	OPERATING WEIGHT	394,315
Payload		485,650
ZERO FUEL WEIGHT		879,965
Fuel		177,849
GROSS WEIGHT		1,057,814

This should be contracted with the -400, which is designed for 30,000 hours in or above military mission profile, and thus, 28,600 hours in the above commercial mission profile. The definition of the -400 is applicable to this configuration except as changed for the above noted reasons. Tables F-25, F-26, and F-27 present performance and physical characteristics of the configuration.

LGA-144-451

This option and the -452 were incorporated in order that the cost-effectiveness implications could be assessed for configurations designed to an 18,000-ft cabin pressure.

The -451 configuration has the same fuselage shape as the -400 baseline, but the -451 is designed to 4.6 psi pressure differential across the fuselage skin as opposed to the -400 using 8.2 psi. The reduced pressure allows the fuselage weight to be reduced by about 2000 lb.

Tables F-28, F-29, and F-30 present performance and physical characteristics of the -451 configuration.

LGA-144-452

Like the -451, this configuration is incorporated in the Design Option Study to assess the cost/effectiveness implications of a fuselage designed to accommodate a cabin pressure of 18,000 ft as opposed to the 8000 ft for the -400 and -411.

The -452 has an identical fuselage shape to the -411. As mentioned in the discussion of the -411, an oval fuselage shape is not an ideal shape for a pressure vessel. Hence, as the cabin pressure is reduced, a greater fuselage weight savings is realized. The -411 had additional fuselage frames added to accommodate the pressure. Thus, the -452 with its lower pressure has a fuselage weight reduction of about 3000 lb; a greater saving than the -451 has over the -400.

TABLE F-25

DESIGN AND PERFORMANCE DATA LGA-144-441

FUSELAGE GEOMETRY	
Length (ft)	259
Wetted Area (ft^2)	21,471
Pressure Volume (ft^3)	149,205
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,930	951	1,021
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.0	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	282	65	36
Wing Loading (lb/ft^2)	129.35		

ENGINE	
Thrust (Sea Level Static - lb)	58,960
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	390,000	404,250
Range (nm)	4,000	3,516
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,917	10,609
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

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TABLE F-26

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-441

ITEM	POUNDS	
Wing		113,308
Horizontal Tail		5,567
Vertical Tail		4,682
Fuselage		124,269
Landing Gear		42,578
Nose	5,535	
Main	37,043	
Nacelles/Pylons		9,207
Nacelles	3,905	
Pylons	5,302	
Noise Treatment	0	
Propulsion System		54,455
Engines	38,979	
Thrust Reversers	6,548	
Fuel System	5,458	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		35,082
Auxiliary Power System	1,254	
Surface Controls	8,387	
Instruments	1,600	
Hydraulics and Pneumatics	3,908	
Electrical	4,008	
Avionics	2,400	
Furnishings	7,556	
Air-conditioning and Anti-ice	5,776	
Auxiliary Gear-Equipment	194	
Weight Empty		389,150
Operating Equipment		12,622
Operating Weight		401,772
Payload		390,000
Zero Fuel Weight		791,772
Fuel		256,769
Gross Weight		1,048,541
AMPR Weight		325,949

TABLE F-27
SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-441

LGA-144-441	OPERATING WEIGHT	401,772
Delete:		
Ramp Extensions	3,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	280	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,850	
Tiedown Rings	1,250	
Loadmasters	440	
Total	14,250	
LGA-144-441C	OPERATING WEIGHT	387,522
Payload		404,250
ZERO FUEL WEIGHT		791,772
Fuel		256,769
GROSS WEIGHT		1,048,541

TABLE F-28

DESIGN AND PERFORMANCE DATA LGA-144-451

FUSELAGE GEOMETRY

Length (ft)	259
Wetted Area (ft^2)	21,471
Pressure Volume (ft^3)	149,205
Cargo Compt L x W x H (ft)	184.6 x 27.3 x 14.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,813	926	1,003
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.10	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	281	65	35
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE

Thrust (Sea Level Static - lb)	57,967
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	390,000	404,250
Range (nm)	4,000	3,520
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	7,916	10,614
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-29

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-451

ITEM	POUNDS	
Wing		106,872
Horizontal Tail		5,436
Vertical Tail		4,611
Fuselage		122,239
Landing Gear		42,301
Nose	5,499	
Main	36,802	
Nacelles/Pylons		9,059
Nacelles	3,852	
Pylons	5,207	
Noise Treatment	0	
Propulsion System		53,532
Engines	38,234	
Thrust Reversers	6,423	
Fuel System	5,405	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		33,776
Auxiliary Power System	1,240	
Surface Controls	8,273	
Instruments	1,599	
Hydraulics and Pneumatics	3,855	
Electrical	4,004	
Avionics	2,400	
Furnishings	7,556	
Air-conditioning and Anti-ice	4,657	
Auxiliary Gear-Equipment	191	
Weight Empty		377,827
Operating Equipment		12,479
Operating Weight		390,305
Payload		390,000
Zero Fuel Weight		780,305
Fuel		252,634
Gross Weight		1,032,940
AMPR Weight		315,514

TABLE F-30

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-451

LGA-144-451		OPERATING WEIGHT	390,305
Delete:			
Ramp Extensions	3,800		
Relief Crew Furnishings	700		
Cargo Winch	340		
Loading Stabilizer Struts	280		
Aerial Refueling Receptacle	120		
Tanker Kit Scar Weight	1,470		
Tiedown Equipment	5,850		
Tiedown Rings	1,250		
Loadmasters	440		
Total	14,250		
LGA-144-451C		OPERATING WEIGHT	376,055
Payload			404,250
ZERO FUEL WEIGHT			780,305
Fuel			252,635
GROSS WEIGHT			1,032,940

Tables F-31, F-32, and F-33 present the performance and physical characteristics of the -452.

TABLE F-31

DESIGN AND PERFORMANCE DATA LGA-144-452

FUSELAGE GEOMETRY	
Length (ft)	261
Wetted Area (ft^2)	20,904
Pressure Volume (ft^3)	133,577
Cargo Compt L X W X H (ft)	184.6 x 27.3 x 11.0
Forward Aperture Width (ft)	27.3
Aft Aperture Width (ft)	None

SURFACE GEOMETRY	WING	HORIZ	VERT
Area (ft^2) (Basic)	7,814	947	872
Sweep (1/4 chord, deg)	25	25	30
Aspect Ratio (Basic)	10.10	4.50	1.25
Taper	0.37	0.35	0.80
Span (ft)	2.81	65	33
Wing Loading (lb/ft^2)	129.35	-	-

ENGINE	
Thrust (Sea Level Static - lb)	58,214
TSFC (Cruise lb/lb/hr)	0.594

PERFORMANCE	MILITARY CONFIG	CIVIL CONFIG
Payload (lb)	390,000	404,250
Range (nm)	4,000	3,500
Cruise Mach	0.78	0.78
Takeoff distance over 50 ft obstacle (ft)	9,500	-
Critical field length/ FAA field length (ft)	8,063	10,613
Second segment climb gradient (%)	2.5	2.5
Landing gear flotation (LCG)	III	III

TABLE F-32

GROUP WEIGHT SUMMARY - MILITARY CONFIGURATION LGA-144-452

ITEM	POUNDS	
Wing		106,786
Horizontal Tail		5,523
Vertical Tail		4,181
Fuselage		121,215
Landing Gear		42,290
Nose	5,498	
Main	36,793	
Nacelles/Pylons		9,096
Nacelles	3,865	
Pylons	5,230	
Noise Treatment	0	
Propulsion System		53,811
Engines	38,419	
Thrust Reversers	6,454	
Fuel System	5,467	
Miscellaneous	2,000	
Tanker Scar Wt.	1,470	
Systems and Equipment		33,609
Auxiliary Power System	1,240	
Surface Controls	8,288	
Instruments	1,602	
Hydraulics and Pne tics	3,862	
Electrical	4,014	
Avionics	2,400	
Furnishings	7,501	
Air-conditioning and Anti-ice	4,511	
Auxiliary Gear-Equipment	191	
Weight Empty		376,510
Operating Equipment		12,456
Operating Weight		388,966
Payload		390,000
Zero Fuel Weight		778,966
Fuel		254,301
Gross Weight		1,033,267
AMPR Weight		314,016

TABLE F-33

SUMMARY OF WEIGHT CHANGES TO GET COMMERCIAL CONFIGURATION LGA-144-452

LGA-144-452	OPERATING WEIGHT	388,966
Delete:		
Ramp Extensions	3,800	
Relief Crew Furnishings	700	
Cargo Winch	340	
Loading Stabilizer Struts	280	
Aerial Refueling Receptacle	120	
Tanker Kit Scar Weight	1,470	
Tiedown Equipment	5,850	
Tiedown Rings	1,250	
Loadmasters	440	
Total	14,250	
LGA-144-452 C	OPERATING WEIGHT	374,716
Payload		404,250
ZERO FUEL WEIGHT		778,966
Fuel		254,301
GROSS WEIGHT		1,033,267

DESIGN OPTIONS AND ASSOCIATED [illegible] NUMBERS

GROUP	DESIGN FEATURES	DESIGN OPTIONS	[illegible]	DERIVED FROM
I	Design Payload	495,000 [illegible]*	[illegible]	
		450,000 [illegible]	[illegible]	[illegible]
		405,000 [illegible]	[illegible]	[illegible]
		360,000 [illegible]	[illegible]	[illegible]
		315,000 [illegible]	[illegible]	[illegible]
II	Loading Unloading Apertures	Front & [illegible]	-20	[illegible]
		Front on [illegible]	[illegible]	-20
	Planform Shape of Cargo Compartment	Tapered forward and aft*	-20	
		Full width forward and aft	-2[illegible]	-2[illegible]
		Full width forward and tapering aft (with airdrop capability)	-2[illegible]	-20
		Full width forward and tapering aft (with no airdrop capability)	-2[illegible]	[illegible] -2[illegible]
	Floor Height	8 ft kneeled and 13 ft [illegible]*	-20	
		13 ft, no kneeling capability	-2[illegible]	-20
III	Takeoff Distance/ Gear Flotation	8,000 ft LCG [illegible]	-3[illegible]	-3[illegible]
		9,500 ft LCG [illegible]*	-3[illegible]	-20
		10,500 ft/LCG [illegible]	-3[illegible]	-3[illegible]
		9,500 ft/LCG II	-3[illegible]	-3[illegible]
		10,500 ft/LCG II	-3[illegible]	-3[illegible]
	Noise Characteristics/ Engine-Out Climb Gradient	No special acoustic treatment, [illegible]*	[illegible], -3[illegible], -3[illegible]	
		Conform to FAR 36/[illegible]	[illegible], -3[illegible], -3[illegible]	[illegible], -3[illegible], -3[illegible]
IV	Cargo Envelope (Maximum Height)	Constant 13.5 ft*	-40	-2[illegible]
		Constant 11 ft	-4[illegible]	-40
	Passenger Provisions	None (except [illegible])*	-40	
		Integral high density passenger accommodations	-4[illegible]	-40
		Integral medium density passenger accommodations	-4[illegible]	-40
		Modular high density passenger accommodations	-4[illegible]	-40
		Integral and modular medium density passenger accommodations	-4[illegible]	-4[illegible]
	Maximum Structural Payload	Corresponds to design range* (i.e., the design payload)	-40	
		Corresponds to [illegible] n mi flight with takeoff at maximum gross weight	-4[illegible]	-40
		Corresponds to [illegible] n mi flight with takeoff at maximum gross weight	-4[illegible]	-40
	Service-Life Specification	[illegible] hrs, [illegible] mission profiles*	-40	
		[illegible] hrs, [illegible] operational profiles	-41	-40
	Pressurization	8,000 ft [illegible] flight altitude*	-40	
		18,000 ft with [illegible] fuselage cross section	-45	-40
		18,000 ft with [illegible] fuselage cross section	-45	[illegible]

* Incorporated in baseline aircraft (Model LGA 144 [illegible])